FREDERICK COUNTY STORMWATER RESTORATION PLAN

JUNE 30, 2016

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ACKNOWLEDGEMENTS

This Plan is a product of several decades of cumulative planning and restoration efforts on the part of Frederick County Government staff, community partners, and consultants. The Plan is also a collaborative project between Staff, two Hood College interns, two Chesapeake Conservation Corps members, and subject matter experts.

Matthew Witmer volunteered on this project with OSER for over a year, only having a formal internship through Hood College his last semester. He worked with staff in the Office of Sustainability and Environmental Resources to refine lists of completed projects, field verify project conditions, research engineering drawings, review every project in every plan ever commissioned or completed for stormwater compliance, and develop modeling scenarios in MAST and BayFAST. Matt's efforts on this project earned him a 2016 Sustainability Award from the Frederick County Sustainability Commission. Notably, he saved the County over $70,000 due to his efforts.

Lia Miller and Louisa McIver worked on this project as part of their Chesapeake Conservation Corps service with OSER. They completed GIS analyses that provided the majority of the inputs for the WTM, sometimes having to redo the inputs several times when model versions were switched or data interpretations changed. They provided all of the map exhibits for the Plan. They developed the calibrated and disaggregated Baseline scenarios in the BayFAST model using an instruction set from KCI, and developed all of the exports and pivot tables. They also inputted restoration projects into the MAST and BayFAST scenarios.

Brad Goodman worked on the *E. coli* TMDL Restoration Plans as graduate student intern with the Frederick County Sustainability Commission. He conducted literature reviews, researched sediment relationships to bacteria transport, wrote portions of the plans (particularly the Sources of Impairment and Control), developed GIS analyses to provide data for the Watershed Treatment Model, worked with County agencies to obtain data, and coordinated with Hood College and the Chesapeake Bay Foundation on a future sampling protocol.

Mary McCullough of Frederick County's GIS office provided a substantial amount of GIS support for the project, to include mentoring OSER's interns and Corps members to develop GIS analyses.

Darlene Bucciero coordinates the Capital Improvement Program and developed the Financial Assurance Plan, which includes the programmed CIP schedule and costs.

Bill Frost of KCI provided a great deal of support on the *E. coli* TMDL Restoration Plans and had thoroughly explored all of the available models and data on the subject. He helped significantly with references from the literature. KCI provided general modeling guidance for the County's efforts and wrote sections of the 2015 Annual Report that included the baseline data for all TMDLs.

ACRONYMS AND ABBREVIATIONS

BMP: Best Management Practice

BR: Bioretention

CAA: Clean Air Act

CFR: Code of the Federal Register

CFU: Colony Forming Units

CBP: Chesapeake Bay Program

CWA: Clean Water Act

E.coli: Escheria Coli

FIB: Fecal Indicator Bacteria

BayFAST: Chesapeake Bay Facility Assessment Scenario Tool

BRF: Chesapeake Bay Restoration Fund

EDSW: Wet Extended Detention Pond

FPU: Forestation on Pervious Urban

IB: Infiltration Basin

IC: Impervious Cover

IMPF: Impervious Surface Elimination to Forest

LULC: Land Use Land Cover

MAST: Maryland Assessment Scenario Tool

MDE: Maryland Department of the Environment

MFSG: Municipal and Financial Services Group

MPN: Most Probable Number

MPR: Maximum Practicable Reduction

MS4: Municipal Separate Storm Sewer System

NPDES: National Pollutant Discharge Elimination System

OSER: Office of Sustainability and Environmental Resources

P3: Public-Private Partnership

PPKT: Pocket Pond

Plan: Frederick County Stormwater Restoration Plan, Includes Impervious Cover Restoration Plan, 12 local TMDL and 2 Chesapeake Bay TMDL Restoration Plans.

RR: Runoff Reduction

SF: Sand Filter

SSO: Sanitary Sewer Overflow

ST: Stormwater Treatment

STRE: Stream Restoration

Stormwater Accounting Guidance: Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated document by MDE

TMDL: Total Maximum Daily Load

WIP: Watershed Implementation Plan

WP: Wet Pond

WSHW: Shallow Marsh

WTM: Watershed Treatment Model

WWTP: Wastewater Treatment Plant

EXECUTIVE SUMMARY

This Frederick County Stormwater Restoration Plan satisfies the requirements of PART IV.E.2.a and b of the NPDES MS4 permit 11-DP-3321 MD0068357 dated December 30, 2014 for the Impervious Cover Restoration Plan and Total Maximum Daily Load (TMDL) Restoration Plans. The Restoration Plan addresses twelve TMDLs for local waterways, two for the Chesapeake Bay, and an impervious surface restoration requirement. The plan is due to MDE on June 30, 2016. This Plan demonstrates that Frederick County Government is on track to meet the restoration efforts required under its current permit and has a long term plan to address its portion of stormwater wasteload allocations for all TMDLs in Frederick County.

All Restoration Plans use a multi-pronged approach that includes stormwater practices. These stormwater practices include volumetric practices like bioretention and pond retrofits, as well as alternative practices for stormwater like riparian buffer planting and stream restoration models. Best Management Practices used are predominantly from MDE's *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated, Guidance for National Pollutant Discharge Elimination System Stormwater Permits* (MDE SW 2014). This document determines how impervious acres are accounted and uses most pollutant removal efficiencies from the Chesapeake Bay Program. These practices were modeled in BayFAST for local TMDLs, MAST for Chesapeake Bay TMDLs, and WTM version 2013 for *E. coli* TMDLs. For *E. coli*, best Management practices in the Watershed Treatment Model version 2013 were supplemented with literature values and SSO loads calculated by the Division of Utilities and Solid Waste Management.

The individual plans in this document are organized by Restoration Tier. Restoration Tiers include Baseline, Completed, Programmed, Identified, and Potential scenarios. Baselines are the TMDL loads without restoration Best Management Practices. Completed projects were finished after March 11, 2007, the expiration date of the previous permit and December 30, 2014, the start date of the current permit. Programmed projects are programmed into the County's Capital Improvement Program and other programs during the permit term, which is set to expire December 30, 2019. Identified projects can be found in Watershed Management Plans, Restoration and Retrofit Assessments, Stormwater Master Plans, and other documents completed by Frederick County Government and its partners and consultants to identify watershed restoration opportunities. Potential Projects are hypothetical projects based on the most cost-effective BMP types and acres of available land.

The Impervious Cover Restoration Plan in this document plans for the permit requirement to restore 20% of the County's untreated urban impervious area (area where water can not percolate) using best management practices for stormwater. The County has 5,063 acres estimated in its impervious cover baseline. 20% of this number is 1,013 acres. At least half of this number, or 506.5 acres, must be met through restoration projects approved in MDE's stormwater accounting guidance (2014). The County has completed 160.5 acres of restoration towards its impervious cover restoration requirements, and has an additional 852.5 acres programmed. The County anticipates completing 757.2 acres of physical restoration towards the MS4 permit requirement by the end of the permit cycle on December 30, 2019. Per MDE, the remainder can be met through credit exchanges in its nascent trading program. The details of this program are evolving. The County can address the remaining impervious surface restoration obligation of 255.8 acres through such trades. If restoration projects have scheduling problems due to permits or other unforeseen circumstances, the County reserves the right to use up to 506.5 acres from trading, commensurate with half of the 20% restoration requirement.

The twelve local TMDLs addressed in this document are in the table below. The TMDLs address impairments from nitrogen, phosphorus, sediment and *E. coli*. Each TMDL's SW-WLA for Frederick County Government's MS4 has its own TMDL Restoration Plan within this Stormwater Restoration Plan.

Table 1: Frederick County Local TMDLs with SW-WLAs and Reductions met by TMDL Restoration Plans

Segment	Impairment	SW-WLA	Reduction	Units
Catoctin Creek	Phosphorus	6,930.61	856.59	Lbs/yr
Catoctin Creek	Sediment	2,368,415.20	2,284,659.83	Lbs/yr
Double Pipe Creek	Phosphorus	364.68	986.01	Lbs/yr
Double Pipe Creek	Sediment	268,810.18	236,472.12	Lbs/yr
Double Pipe Creek	*Escherichia coli*	165,132.7	163,151.1	Billion MPN/yr
Lower Monocacy River	Phosphorus	20,417.98	7,940.32	Lbs/yr
Lower Monocacy River	Sediment	3,858,598.30	5,984,764.70	Lbs/yr
Lower Monocacy River	*Escherichia coli*	1,700,789.7	1,573,230.4	Billion MPN/yr
Potomac River Mo. County	Sediment	20,442.29	11,598.91	Lbs/yr
Upper Monocacy River	Phosphorus	867,710.8	255.46	Lbs/yr
Upper Monocacy River	Sediment	6,131.04	1,164,371.32	Lbs/yr
Upper Monocacy River	*Escherichia coli*	1,211,896.70	841,679.4	Billion MPN/yr

The Chesapeake Bay TMDL for nitrogen includes all best management practices required to meet all other TMDLs with the exception of some programmatic BMPs for *E. coli*. For this reason the Chesapeake Bay TMDL Restoration Plan for Nitrogen governs the schedules and costs for all other TMDLs. The Chesapeake Bay TMDLs for Nitrogen and Phosphorus include SW-WLAs that were calibrated for Frederick County Government's MS4. The SW-WLAs are addressed by this Plan.

Table 2 - Frederick County Chesapeake Bay TMDL Baseline and Target Loads

Baseline and Target	TN EOS lbs/yr	TN DEL lbs/yr	TP EOS lbs/yr	TP DEL lbs/yr
Calibrated 2010 Baseline Load	1,096,458.45	556,694.68	46,994.58	22,046.67
Target Percent Reduction	10.2%	10.9%	20.7%	20.7%
Calibrated Target Reduction	111,838.76	60,679.72	9,727.88	4,563.66
Calibrated Bay TMDL SW-WLA	984,619.69	496,015.00	37,266.70	17,483.01

The following loads achieved under the Chesapeake Bay TMDL Restoration Plan for Nitrogen also address all other local nutrient and sediment TMDL SW-WLAs for the MS4:

Table 3: Edge of Stream and Delivered loads in Chesapeake Bay Nitrogen TMDL Restoration Plan

Segment	Acres	N Load EOS	N Load DEL	P Load EOS	P Load DEL	S Load EOS	S Load DEL
Catoctin Creek	7653.64	167072	54504.11	4975.96	2334.39	3173334.28	2055982.09
Double Pipe Creek	1427.22	29717.89	7387.7	1008.94	473.33	573474.29	371550.14
Lower Monocacy River	31835.76	555804.52	313074.87	10562.94	4955.43	2632748.7	1705740.28
Potomac River FR Cnty	3656.79	76127.69	56101.74	3022.12	1417.77	1329669.91	861484.23
Potomac River MO Cnty	53	1144.09	886.3	51.1	23.97	19422.4	12583.64
Upper Monocacy River	7532.97	153151.39	64046.82	3849.06	1805.72	1534041.09	993894.94
Grand Total	52159.38	983017.58	496001.54	23470.12	11010.61	9262690.67	6001235.32

The Potomac River Sediment TMDL SW-WLA for the MS4 is expected to be met during the current permit term.

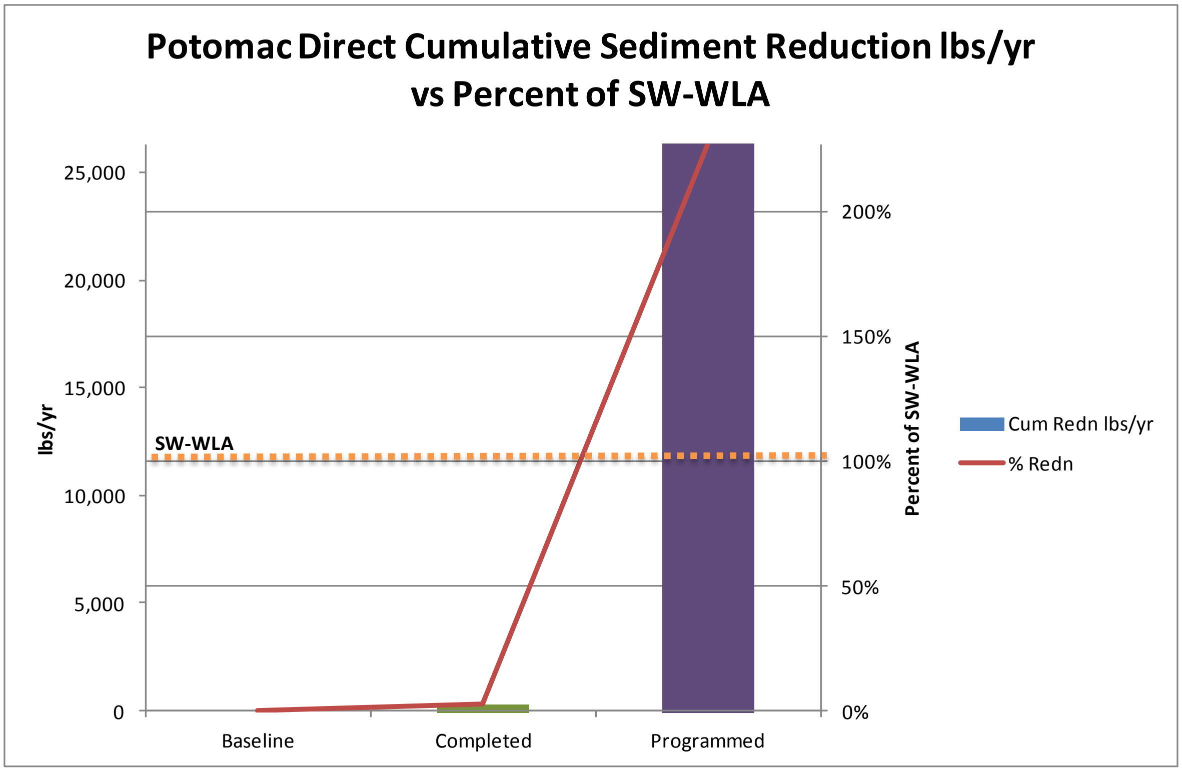


Figure 1: Potomac Direct Cumulative Sediment Reductions lbs/yr vs. Percent of SW-WLA 100% Complete within Permit Term

The *E. Coli* TMDL SW-WLAs were met in all final scenarios for Double Pipe Creek (1,981.6 Billion MPN/year), Lower Monocacy River (127,559.2 Billion MPN/year), and Upper Monocacy River (26,031.3 Billion MPN/year). In Double Pipe Creek, a reduction amount of 165,755.7 Billion MPN/year was achieved, representing 100.38% of the required reduction. In the Lower Monocacy River, a reduction amount of 3,114,414.1 Billion MPN/year was achieved, representing 183.12% of the required reduction. In the Upper Monocacy River, a reduction amount of 1,137,559.2 Billion MPN/year was achieved, representing 131.1% of the required reduction. Neither the Upper Monocacy nor the Lower Monocacy SW-WLAs could be met without reducing SSOs. Both could be met by the end of the Programmed permit term by including SSO reductions. Double Pipe Creek had no SSOs for Frederick County. In addition to practices used in nutrient and sediment TMDLs, *E. coli* BMPs include education; septic system practices; and illicit connection removal.

The Upper Monocacy and Lower Monocacy Watershed *E. coli* TMDL SW-WLAs for the MS4 are expected to be met during the current permit term.

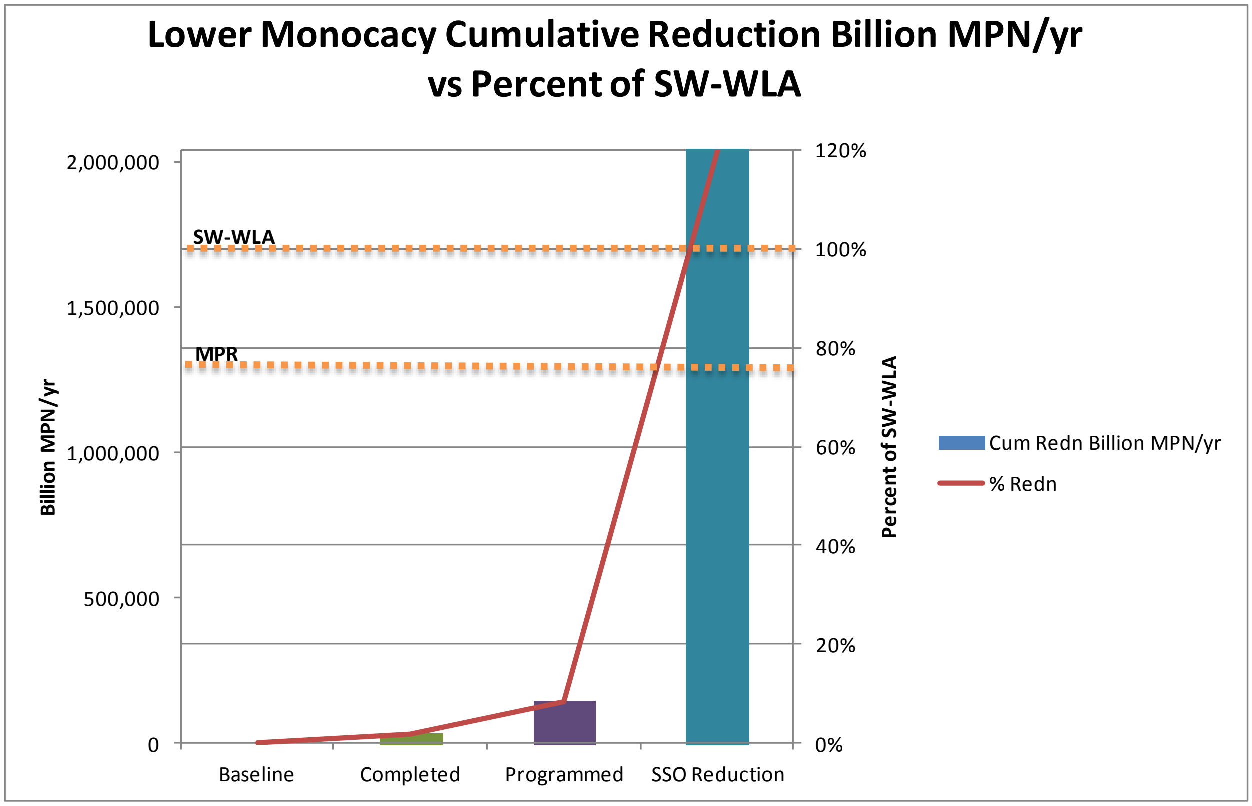


Figure 2: Lower Monocacy Cumulative Reduction Billion MPN/yr versus Percent of SW-WLA

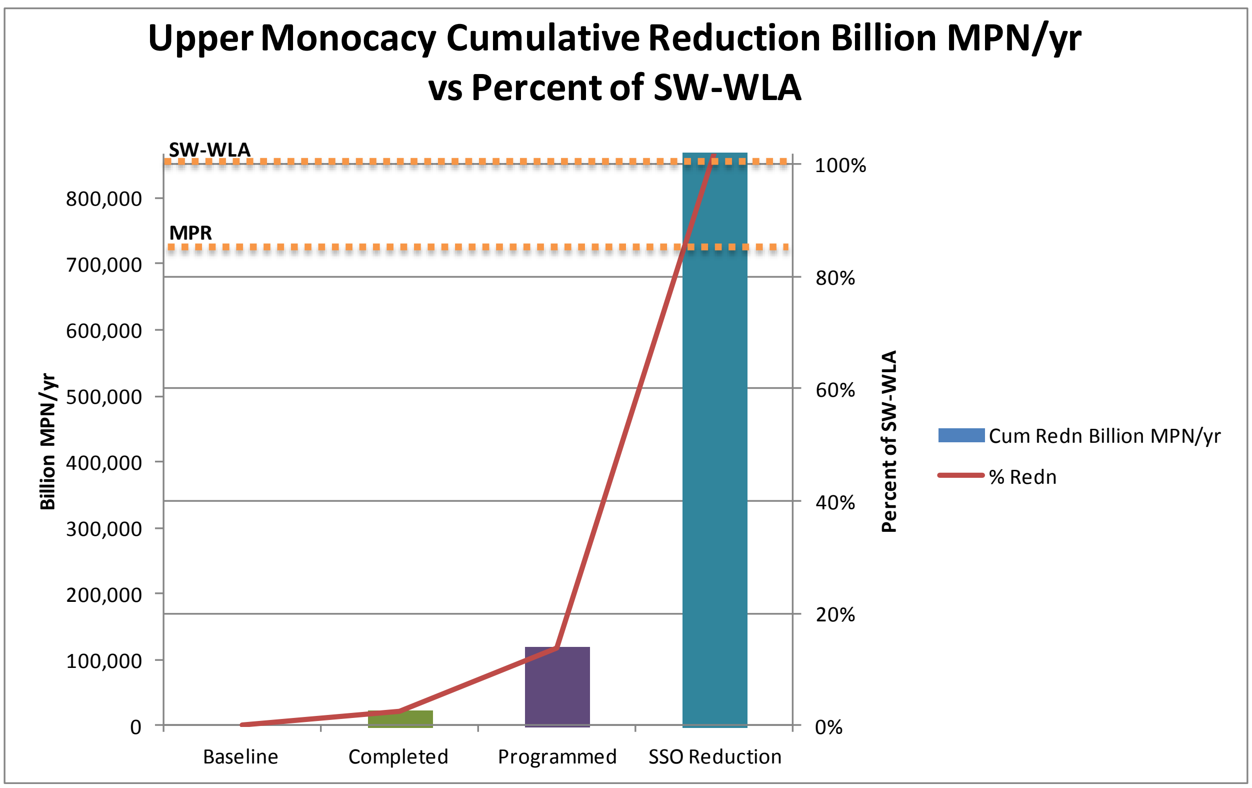


Figure 3: Upper Monocacy Cumulative Reduction Billion MPN/yr versus Percent of SW-WLA

Table 4: Summary of SW-WLA *E. coli* Reductions by Watershed

Watershed	Scenario	Reduction Amount Billion MPN/year	% Reduction
Double Pipe Creek	Cumulative Reduction	165,755.7	100.38%
	MPR EXCEEDED	133,427.2	80.8%
	TMDL WLA EXCEEDED	163,151.1	98.8%
Lower Monocacy River	Cumulative Reduction	2,041,410.3	120.0%
	MPR EXCEEDED	1,293,620.6	76.06%
	TMDL WLA EXCEEDED	1,573,230.4	92.5%
Upper Monocacy River	Cumulative Reduction	884,898.6	102.0%
	MPR EXCEEDED	740,398.4	85.3%
	TMDL WLA EXCEEDED	841,679.4	97.0%

This Frederick County Stormwater Restoration Plan satisfies the requirements of PART IV.E.2.a and b of the NPDES MS4 permit 11-DP-3321 MD0068357 dated December 30, 2014 for the Impervious Cover Restoration Plan and Total Maximum Daily Load (TMDL) Restoration Plans. The Plan will take a cumulative 268.81 years to complete (259.5 years from today's date), will restore an estimated 13,435.69 impervious acres and will cost a cumulative amount of $1,085,566,756.

Table 5: Timeframes, Cumulative Acres and Cumulative Costs by Tier for Stormwater Restoration Plan

Scenario	Begin Date	Complete Date	Cum Duration Years	Cum Acres	Cost
Complete	3/11/2007	12/30/2014	7.81	106.5	$10,192,516
Programmed	12/30/2014	12/30/2019	12.81	1013	$48,582,365
Identified	12/30/2019	12/16/2073	66.81	3784.21	$217,140,365
Potential	12/16/2073	10/29/2275	268.81	13435.69	$809,651,510
Total					**$1,085,566,756**

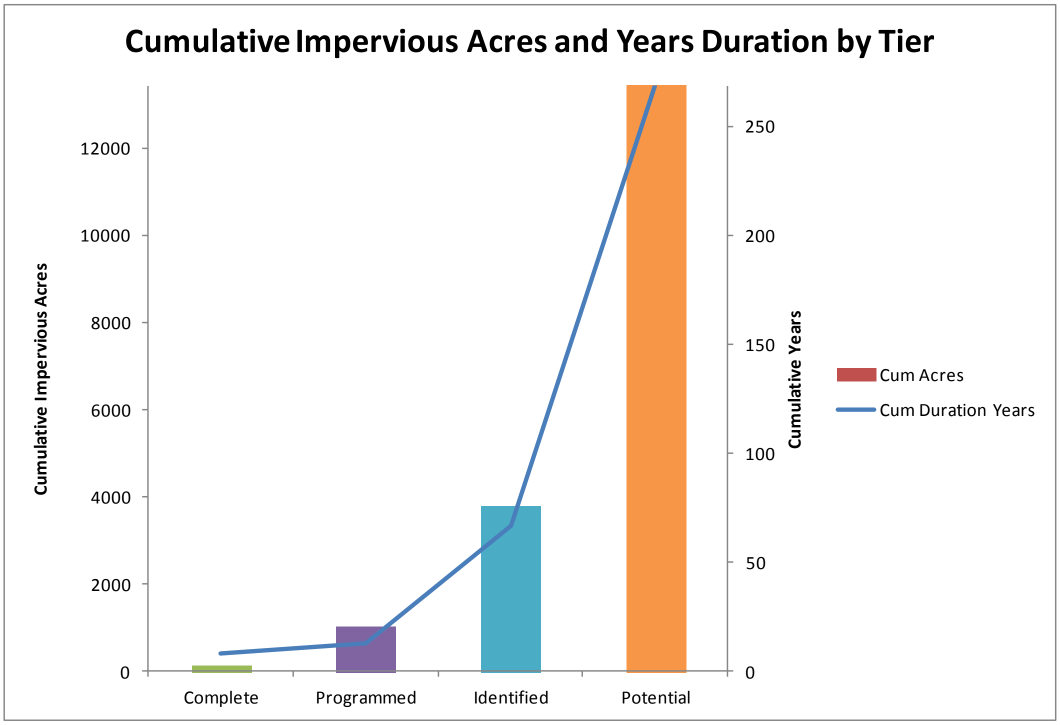


Figure 4: Cumulative Impervious Acres and Years Duration by Tier for Stormwater Restoration Plan:

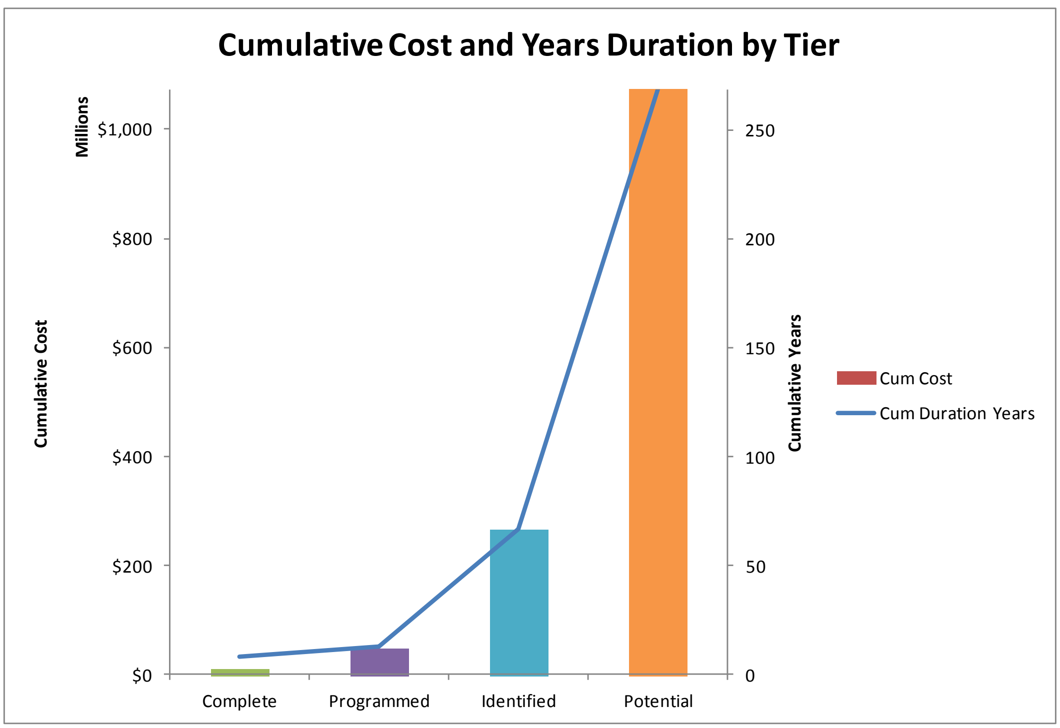


Figure 5: Cumulative Costs and Years Duration by Tier for Stormwater Restoration Plan

A previous cost estimate for the Frederick County MS4 SW-WLA for the Chesapeake Bay TMDL was in the TMDL Local Area Plan that Frederick County Government submitted to meet requirements for the Phase II Watershed Implementation Plan. That document estimated the cost at $652,497,347; however, several significant differences exist between that plan and this one. The WIP included several thousand acres of urban nutrient management. That practice, the cheapest of all accepted practices, was allowed in a previous version of the Stormwater Accounting Guidance but is not in the 2014 version because of the statewide fertilizer law. The WIP also included several thousand acres of infiltration practices, which Brown and Caldwell (2014) determined were not suitable to most Frederick County soils; this also removed a very cost effective practice. The Brown and Caldwell cost estimates are less expensive for forest than the King and Hagen estimates used for the WIP, but other practices like bioswales are more expensive due to Frederick County soils. The acre basis is also different; this Stormwater Restoration Plan is based on very specific instructions from MDE for calibration and disaggregation, where the Local Area Plan assumed a general land use percent of the total.

This document relies on currently accepted practices to meet the pollutant and impervious cover restoration requirements that are required by the MS4 permit and the Stormwater Accounting Guidance; however, it is clear in the case of Frederick County that more cost-effective alternatives must be considered in the future in order to address the TMDL. The question should be asked: what is the most cost effective way to reduce the pollutants in the local and Bay TMDLs? The answer to that will likely include a number of key concepts:

1. Reduction of atmospheric deposition of nitrogen: the Chesapeake Bay TMDL 2010 baselines from EPA originally included atmospheric deposition reductions from nitrogen due to portions of the Clean Air Act that were implemented. Future actions, such as the low sulfur fuels standard, were not included. Future versions of EPA allocations will likely show additional reductions from expanded implementation of the CAA and other air rules. Maryland applied reductions from its own Clean Cars Act and Healthy Air Act to open water, as no BMPs currently exist for this land use; however if the reductions occur across the land they should be more evenly distributed. EPA also allowed the state to count 50% of the reductions from its actions in early versions of the state's WIP; a more sophisticated modeling approach should be used that reflects actual deposition. Other states also have engaged in atmospheric pollutant reductions, and these reductions will also benefit Maryland. Since the Chesapeake Bay TMDL for Nitrogen governs Frederick County's schedules, reduction of Nitrogen has a direct bearing on the cost and timeframes of Frederick County's plan. Consideration should also be given for BMPs that the County implements to reduce atmospheric pollution, such as the conversion of its bus fleet to all-electric.
2. The Maryland Department of the Environment is developing a water quality trading program that will be developed in the latter half of 2016. This could allow for other kinds of practices like agricultural cover crops to substitute for urban stormwater practices. Urban stormwater practices are the most expensive practices for Bay restoration.
3. Large scale education and management programs for pet waste and urban fertilization could provide a cost-effective way of reducing pollution that is not currently part of the Stormwater Accounting Guidance.
4. Public procurement is designed to protect the public's interests but also has a great deal of overhead; to reduce the cost per acre below the $79,932 estimated for this plan, multiple options should be considered:
    a. Grant issuances: Several jurisdictions have issued RFPs asking for bids on the most cost effective pollutant and impervious area reductions. Others have worked with the Chesapeake Bay Trust to issue grant opportunities that the Trust manages for a minimum amount of overhead. In both options, the public procurement is reduced and private and non-profit entities can compete on a price basis.
    b. Public-Private Partnerships: A longer-term relationship model for Public-Private Partnerships (P3s) exists. Essentially the private partner implements the restoration and maintenance efforts and is responsible for specific performance metrics like cost per acre restored or pound of pollutant reduced. The partner can provide long-term financing. The County pays the private partner through bonds or another revenue source.

INTRODUCTION

Ballenger Creek Stream Restoration Time Series

PLAN REQUIREMENTS

This Restoration Plan satisfies the requirements of PART IV.E.2.a and b of the NPDES MS4 permit 11-DP-3321 MD0068357 dated December 30, 2014 for the Impervious Cover Restoration Plan and Total Maximum Daily Load (TMDL) Restoration Plans. The Restoration Plan addresses twelve TMDLs for local waterways, two for the Chesapeake Bay, and a 20% impervious surface restoration requirement. The TMDLs address impairments from nitrogen, phosphorus, sediment and *E. coli*. This Plan should be viewed as a planning document that is subject to the County's review and revision in future years consistent with adaptive management, which is a cornerstone of any good stormwater program. The plans include estimated dates and costs for completion of various projects that may change over time. The County preserves the right to substitute projects based on lessons learned in earlier years. This plan assumes certain efficiencies for BMPs as a part of the development of the plans. Changes that reduce efficiencies should not be held against the County; however, better information that improves efficiencies should be captured in future plan revisions. The County's ability to implement milestone actions depends on approval and funding from the local governing body in future years. This Assessment is subject to future refinement by the County based on new or additional information.

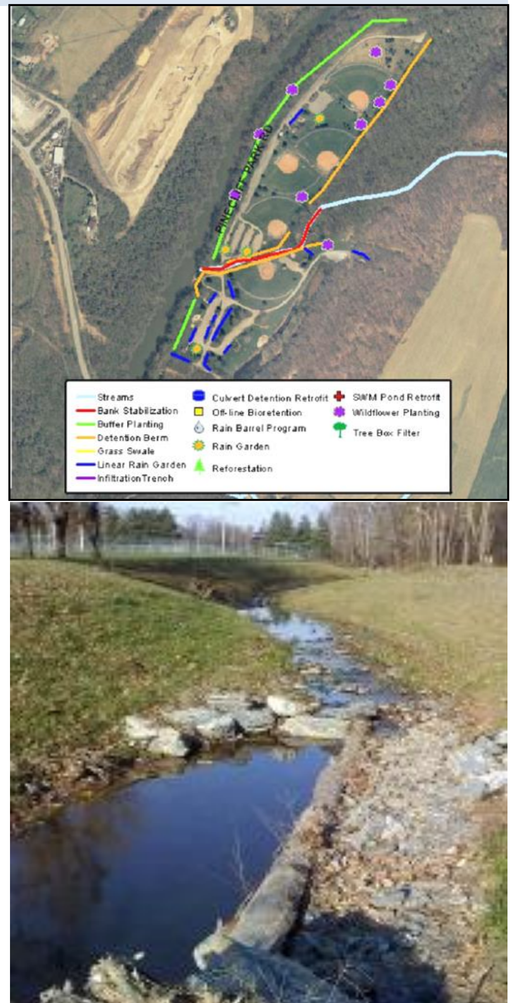


Figure 6: Pinecliff Park Stream Restoration

NPDES MS4 permit 11-DP-3321 MD0068357, dated December 30, 2014, requires this plan within one year of permit issuance, which would have been December 30, 2015; however, Frederick County's MS4 is currently in Frederick Circuit Court, case number 10-C-15-000293. A Joint Motion for Extend Stay of Proceedings was granted on September 18, 2015, which included "that the County's deadline for submittal of restoration plans pursuant to Part IV.E.2.b of its MS4 permit is **STAYED** and extended until June 30, 2016."

IMPERVIOUS COVER RESTORATION PLAN REQUIREMENTS

Part IV.E.2.a of the permit describes the requirement for the Impervious Cover Restoration Plan:

> *"by the end of this permit term, Frederick County shall commence and complete the implementation of restoration efforts for twenty percent of the County's impervious surface area consistent with the methodology described in the MDE document cited in PART IV.E.2.a. that has not already been restored to the MEP. Equivalent acres restored of impervious surfaces, through new retrofits or the retrofit of pre-2002 structural BMPs, shall be based upon the treatment of the WQv criteria and associated list of practices defined in the 2000 Maryland Stormwater Design Manual. For*

> *alternate BMPs, the basis for calculation of equivalent impervious acres restored is based upon the pollutant loads from forested cover."*

Frederick County is required to restore 20% of the county's impervious surface within the MS4 that is not treated to the MEP by December 30, 2019. It must use standards from MDE's *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated, Guidance for National Pollutant Discharge Elimination System Stormwater Permits* (MDE SW 2014).

TOTAL MAXIMUM DAILY LOAD RESTORATION PLAN REQUIREMENTS

TMDL (Total Maximum Daily Load) is the maximum amount of a pollutant, measured in total number or weight, which a water body can receive while still meeting state water quality standards and designated uses. TMDLs are comprised of two main elements: The first is a Wasteload Allocation (WLA), which includes point sources such as stormwater wasteload allocations (SW-WLA) that include National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4)-regulated urban stormwater permits and Wastewater Treatment Plant permits. The other component is a Load Allocation (LA), which includes nonpoint sources. Nonpoint source examples include loads from agriculture and forested land uses. A TMDL "equation" would look like the expression below:

TMDL = total allowable load to waterway = point sources + nonpoint sources = WLA + LA

This Restoration Plan identifies management actions and practices that will address the portions of the SW-WLAs attributable to the County's MS4 for the 12 local TMDLs in Frederick County for Phosphorus, Sediment and *E. coli* and the two Chesapeake Bay TMDL goals for Nitrogen and Phosphorus.

PERMIT REQUIREMENTS

Per the Permit PART IV.E.2.b, Frederick County must "submit restoration plans for subsequent TMDL WLAs within one year of EPA approval. Upon approval by MDE, these restoration plans will be enforceable under this permit." The plans must include:

- "the final date for meeting applicable WLAs and a detailed schedule for implementing all structural and nonstructural water quality improvement projects, enhanced stormwater management programs, and alternative stormwater control initiatives necessary for meeting applicable WLAs." The final date presented in this document is for the completion of the Nitrogen TMDL for the Chesapeake Bay, as it includes all BMPs for all other TMDLs plus those additionally required to meet the TMDL.
- "detailed cost estimates for individual projects, programs, controls, and plan implementation". "monitoring or modeling to document the progress toward meeting established benchmarks, deadlines, and stormwater WLAs."
- "Development of "an ongoing, iterative process that continuously implements structural and nonstructural restoration projects, program enhancements, new and additional programs, and alternative BMPs where EPA approved TMDL stormwater WLAs are not being met according to the benchmarks and deadlines established as part of the County's watershed assessments."

MDE COMMUNICATIONS: NO DEVELOPMENT SCENARIO

In a conversation with Jim George of Science Services Administration, he advised Frederick County staff to not incorporate development scenarios into the restoration plans. This is because the state plans to address development activity through its upcoming "Aligning for Growth" program. The outcome of this advice is that land use conversion due to development activity after the baseline year is not added to the scenarios, nor are developer-funded stormwater best management practices beyond the baseline year. Land use change from reforestation is included, as it is associated with a restoration BMP. The County has, as part of its NPDES MS4 permit requirements, modeled loads as of the beginning date of its current MS4 permit, December 30, 2014. It also created a current scenario for its first Annual Report in the current permit cycle, current as of July 1, 2015. Consistent with the permit, the County will provide an updated current permit for the end of each permit year in its Annual Reports, due December 30 for the previous fiscal year ending June 30.

NUTRIENT AND SEDIMENT TMDL RESTORATION PLAN REQUIREMENTS

MDE TMDL DATA CENTER

Maryland Department of the Environment published *Guidance for Using the Maryland Assessment Scenario Tool to Develop Stormwater Wasteload Allocation Implementation Plans for Local Nitrogen, Phosphorus, and Sediment TMDLs* in 2014 (MDE MAST 2014). This document governs the elements for these TMDL Restoration Plans. The MDE TMDL Data Center (MDE TMDL Data Center 2016) requires and gives instructions to determine target loads and reduction loads using MAST and BayFAST. All restoration efforts to be implemented must be modeled through these scenario tools and calibrated to represent the same acreages per watershed, as the County plans to use both scenario tools in order to represent the WLA Implementation Plan.

E. COLI RESTORATION PLAN REQUIREMENTS

MDE TMDL DATA CENTER

Maryland Department of the Environment published *Guidance for Developing a Stormwater Wasteload Allocation Implementation Plan for Bacteria Total Maximum Daily Loads* in 2014 (MDE Bacteria 2014). This document governs the elements of the *E. coli* TMDL Restoration Plans. Information needed for disaggregation is found in the MDE TMDL Data Center (MDE TMDL Data Center 2016).

MDE COMMUNICATIONS: MAXIMUM PRACTICABLE REDUCTION

The *E. coli* TMDLs exceed Maximum Practicable Reduction (MPR); in order to address the TMDL, MDE has assigned reductions that are beyond MPR. In its *Comment Response Document Regarding the Total Maximum Daily Loads of Fecal Bacteria for the Lower Monocacy River Basin in Carroll, Frederick, and Montgomery Counties, MD* (2007), MDE responds to a question from Frederick County by saying that:

> *"the reductions in fecal bacteria loads necessary to meet water quality standards in the Lower Monocacy River watershed can not be achieved by implementing effluent limitations and cost-effective, reasonable BMPs to nonpoint sources. Therefore, MDE proposes a staged approach to implementation, beginning with the maximum practicable reduction scenario outlined in the TMDL report, with regularly scheduled follow-up monitoring to assess the effectiveness of the implementation plan. Thus, the*

> *MPRs do not initiate a Use Attainability Analysis, but rather the first stage of a long-term implementation process. MDE's TMDL Implementation Guidance document (2006) envisions TMDL implementation as a partnership between State and local governments, with the local jurisdictions taking the lead in making informed policy decisions and managing relevant programs, and also acquiring the capacity to develop and execute implementation policies and procedures with the guidance, oversight and available resources of the appropriate State agencies.*

There is language in each of the TMDLs stating that the goals of TMDLs are to be broken into phases, with the first phase being MPR. For example in Double Pipe Creek (MDE DP 2009), MDE states that:

> *water quality standards cannot be attained in any of the seven Double Pipe Creek subwatersheds, using the MPR scenario. MPRs may not be sufficient in subwatersheds where wildlife is a significant component or where very high reductions of fecal bacteria loads are required to meet water quality standards. In these cases, it is expected that the MPR scenario will be the first stage of TMDL implementation.*

MDE has developed an MPR for each watershed based on sources. For each TMDL, it assumes an MPR of 95% for human sources, 75% for domestic, 75% for livestock, and 0% for wildlife. The SW-WLAs for these sources include a portion of human sources "beyond the reach of the sanitary sewer system", 100% of the domestic load from pet waste, none of the livestock load, and a portion of the wildlife load "based on a ratio of the amount of pervious non-urban and pervious urban land" (MDE DP 2009). Regarding the human contribution, MDE further explains that:

> *For human sources, if the watershed has no MS4s or other NPDES-regulated stormwater entities, the nonpoint source contribution is estimated by subtracting any WWTP and CSO loads from the TMDL human load, and is then assigned to the LA. However, in watersheds covered by NPDES-regulated stormwater permits, any such nonpoint sources of human bacteria (i.e., beyond the reach of the sanitary sewer systems) are assigned to the stormwater WLA.*

There is neither a calculation for the MPR by sector as opposed to source within the TMDL documents nor the data needed to make the calculation. Neither the TMDL data center nor the guidance for developing bacteria TMDL restoration plans (MDE Bacteria 2014) include any information on MPR or how to address it; for this reason, Frederick County sought guidance from Science Services Administration staff at MDE. MDE staff provided raw spreadsheets that showed the allocations between both sources and sectors in the SW-WLA (email communication Vimal Amin, MDE , 5/20/2016). Frederick County used these spreadsheets to calculate MPR.

PUBLIC PARTICIPATION

As required by Part IV.E.3 of the MS4 Permit (MDE Permit 2015), public participation is required for Frederick County's watershed assessments and restoration plans. The specific requirements include:

1. Notice in a local newspaper indicating a 30-day public comment period for each watershed assessment and restoration plan,
2. Notice in a local newspaper announcing that public information procedures are provided on the County's website for each watershed assessment and restoration plan, and

3. A summary in the Annual Report on public participation activities for each of the watershed assessments and restoration plans.

The Restoration Plan will be posted to the website on May 30, 2016. Public notice will be published in the Frederick News Post on May 31 and June 1. The thirty day review period will go from May 31 to June 30. The report will be submitted to MDE on June 30, 2016. A summary will be published in the Annual Report for Fiscal Year 2016 to be issued December 30, 2016.

RESTORATION TIERS

The County developed its Restoration Plan using the following tiers and definitions:

Figure 7: Restoration Tiers

- **Baseline:** reflects the pollutant loading, impervious surface, and projects in the ground at the time the TMDL or impervious surface goal was established (2000 for sediment and 2009 for nutrients for Local TMDLs; 2010 for nitrogen and phosphorus in the Bay; and 2004 for Local *E. coli* TMDLs). In the case of the Impervious Cover Restoration Plan, the baseline is the end date of the previous MS4 permit, March 11, 2007. These projects in the Baseline do not count as pollutant reductions in any restoration scenario. Instead they are part of the baseline load.
- **Completed:** These projects were completed after March 11, 2007 when the previous five year MS4 permit term ended. They were completed prior to December 30, 2014 when the next permit was issued. The previous permit was administratively extended by MDE during this time period. The projects have been inspected and verified to ensure that they meet MDE's requirements.
- **Programmed:** These projects are programmed in the County's Capital Improvement Program and other programs to be completed between December 30, 2014 and December 30, 2019.
- **Identified:** These projects were identified in a Watershed Management Plan (WMP) or other planning document and will be updated in future Restoration Plans as new assessments become available. These projects have engineering estimates of treated drainage areas including pervious and impervious acres. They will be completed after December 30, 2019. These data were compiled by Matthew Witmer as a Hood College intern. The studies used to develop the Identified scenario tier are listed below. Full bibliographies are in the References section.
    - An Assessment of Stormwater Management Retrofit and Stream Restoration Opportunities in Ballenger Creek Watershed, Frederick County, Maryland.
    - An Assessment of Stream Restoration and Stormwater Management Retrofit Opportunities in Lower Bush Creek Watershed, Frederick County, Maryland.
    - Watershed Assessment of Lower Linganore Creek Frederick County, Maryland.
    - An Assessment of Stormwater Management Retrofit and Stream Restoration Opportunities in Linganore Creek Watershed, Frederick County, MD.
    - Final Report Watershed Assessment of Ballenger Creek Frederick County, Maryland.
    - Watershed Assessment of Lower Bush Creek, Frederick County, Maryland.

- Lower Monocacy River Watershed Restoration Action Strategy (WRAS) Supplement: EPA A-I Requirements.
- Lower Monocacy River Watershed Restoration Action Strategy Frederick County, Maryland Final Report.
- Upper Monocacy River Watershed Restoration Action Strategy Frederick County, Maryland Final Report.
- Bennett Creek Watershed Assessment.
- An Assessment of Stormwater Management Retrofit and Stream Restoration Opportunities in Bennett Creek Watershed, Frederick County, Maryland.
- Chesapeake Bay TMDL Analysis for Frederick County, Maryland.
- Final Analysis of Maximum Extent Practicable for the NPDES MS4 Permit Requirements.

- **Potential:** These projects were selected using best available information on costs per BMP and available land in the models for the TMDL. The most commonly used BMPs implemented by the county (Stream Restoration, Bioswale, and Riparian Forest Buffers) were selected, applied to a ratio proportional to past implementation, and given average sizes based on Brown and Caldwell (2014). They will be completed after December 30, 2019 and after Identified projects.

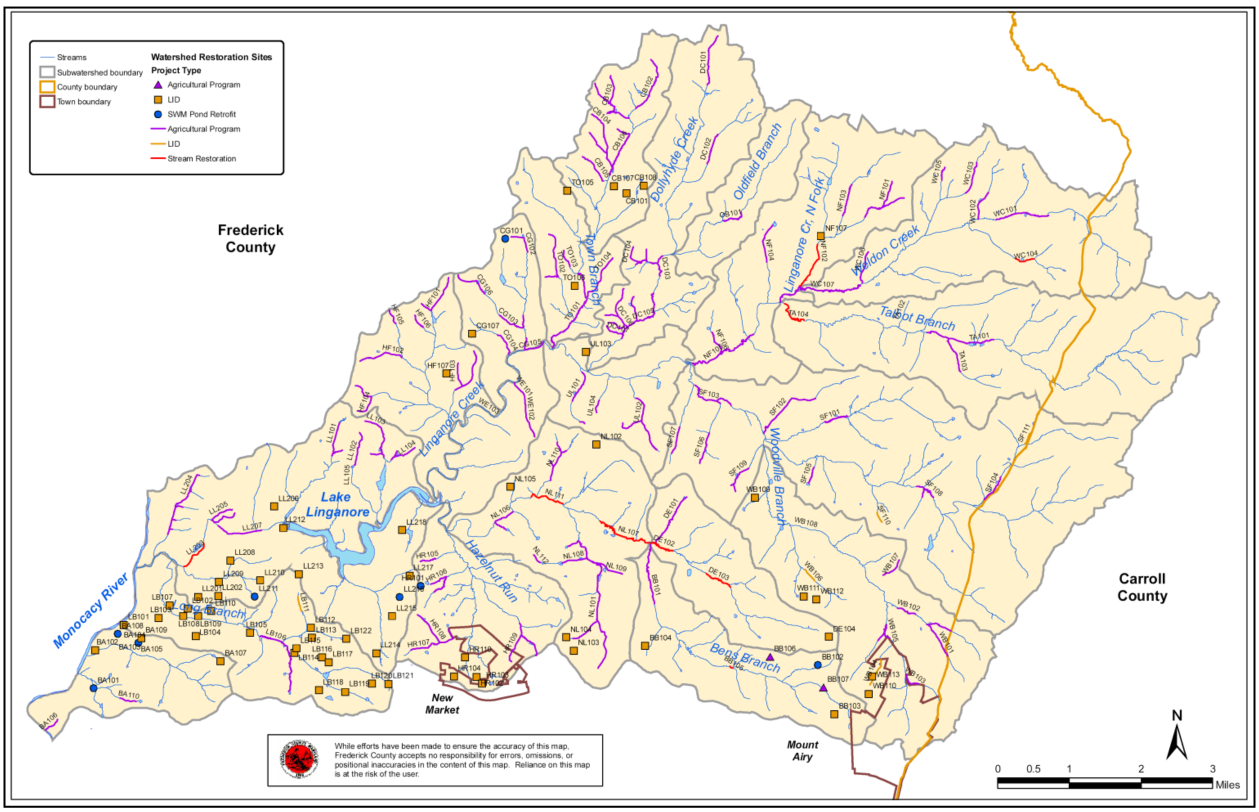


Figure 8: Project Sites Identified in *An Assessment of Stormwater Management Retrofit and Stream Restoration Opportunities in Linganore Creek Watershed, Frederick County*, 2006

UNIQUE PROJECTS AND SCENARIO NESTING

Many of the best management practices for stormwater used to meet this plan can be used in more than one scenario. For example, a programmed (scheduled for completion before December 30, 2019) 103.4 acres of pond retrofits in the Villages of Urbana used to meet the Impervious Cover Restoration Plan will also be used towards the sediment and phosphorus TMDLs for the Lower Monocacy as well as the nitrogen and phosphorus TMDLs for the Chesapeake Bay. These scenarios nest partly or fully inside of each other and have overlapping projects. Because BMPs are duplicated between scenarios in most instances, the schedules and costs for the TMDLs are based on unique projects and are not applied to the local TMDLs. The Chesapeake Bay TMDL Restoration Plan for nitrogen includes all BMPs used in all other scenarios; for this reason this BMP governs costs, schedules and timeframes for the entire Restoration Plan. When this plan is completed, all other TMDLs are completed. Schedules and costs are shown for the subset of projects that are in the Impervious Cover Restoration Plan because these projects reflect the efforts that will be completed in the current permit term prior to its expiration on December 30, 2019. The projects in the Impervious Cover Restoration Plan are consistent with the legislative reporting in the Financial Assurance Plan and Watershed Protection and Restoration Plan reports that are due to MDE on July 1, 2016.

The TMDL Restoration Plans and Impervious Cover Restoration Plan have nested relationships. The Chesapeake Bay nitrogen TMDL contains BMPs for the Chesapeake Bay phosphorus TMDL, all Local TMDLs, and the Impervious Cover Restoration Plan. The Chesapeake Bay phosphorus TMDL contains BMPs for all Local TMDLs, and the Impervious Cover Restoration Plan. The *E. coli* TMDLs include all BMPs from local TMDLs. The local phosphorus TMDL Restoration Plans include BMPs for all local sediment TMDL Restoration Plans. The Impervious Cover Restoration Plan includes all of the BMPs in the Completed and Programmed scenarios for all TMDLs.

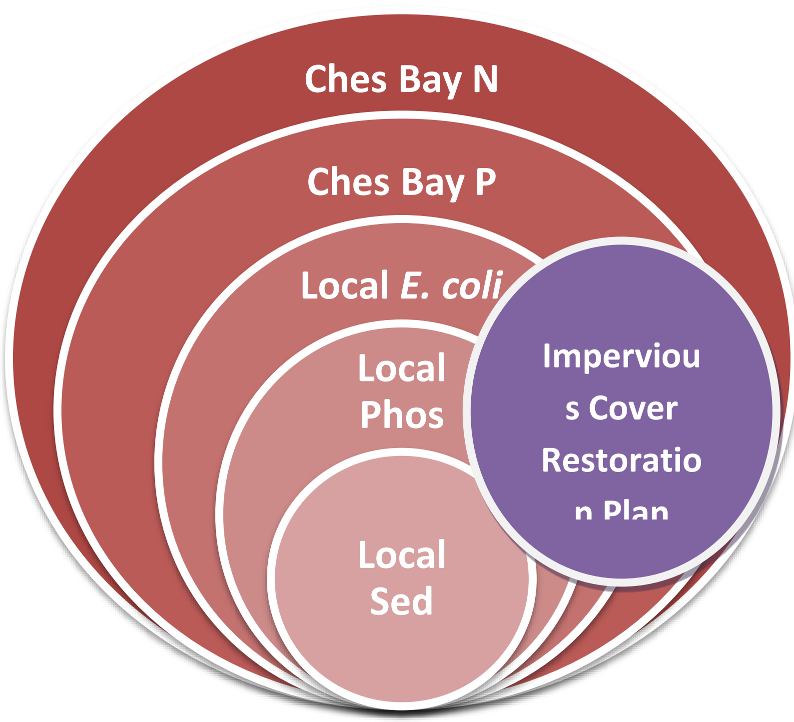


Figure 9: Nested Restoration Scenarios

WATER QUALITY MODELS AND DELIVERY RATIOS

Reductions of nitrogen, phosphorus and sediment for stormwater BMPs are modeled in the Maryland Assessment Scenario Tool (MAST) for the Chesapeake Bay scenarios and in BayFAST for the local TMDLs. These models contain land use loading data and allow the user predict reductions of pollutants by inputting scenarios with individual projects. The tools calculate pollutant reductions based on the size of the practice and standard practice efficiencies. BayFAST and MAST "use CBP-approved BMPs and efficiencies" and are "consistent with the CBP Phase 5.3.2 Watershed Model and updates" (BayFAST 2016). BayFAST allows users to clip their watershed to a facility boundary and to use multiple baselines, which is why this model was chosen for local TMDL modeling. For *E. coli* reductions, the Watershed Treatment Model (WTM) 2013 version was used. This model allows for the input of similar projects plus management efforts specifically to reduce *E. coli* bacteria and is based on a land use land cover model. Some *E. coli* numbers like SSOs are modeled outside of WTM.

Pollutant loadings in this plan are expressed in terms of Edge of Stream (EOS) Loads or Delivered (DEL) Loads. EOS loads apply to local waterways and are used for local TMDLs for Phosphorus, Sediment and *E. coli*. DEL loads estimate the attenuated load that makes its way to the mainstem of the Chesapeake Bay. DEL loads are obtained by subtracting the percentage of the EOS load that is attenuated prior to reaching the Bay. These calculations are performed in the models.

BEST MANAGEMENT PRACTICES USED

All plans in this document include stormwater Best Management Practices accepted by MDE's *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated, Guidance for National Pollutant Discharge Elimination System Stormwater Permits* (MDE SW 2014). This stormwater accounting guidance includes stormwater retrofit projects like wet pond wetland conversions and bioretention facilities as well as alternative practices like tree planting and stream restoration. Stormwater retrofit practices must meet a 1" water quality volume standard. Alternative practices must meet a pollutant load reduction per acre that is the difference between a forested and untreated impervious load.

Practices in the stormwater accounting guidance are measured in terms of impervious acres treated and in reductions of nitrogen, phosphorus, and sediment. Most of the pollutant removal efficiencies for these practices come from the Chesapeake Bay Program, though there are some differences. The Bay Program also does not address impervious acre equivalent, which is Maryland-specific.

A single practice may give impervious acre credit for the Impervious Cover Restoration Plan and pollutant reductions for multiple TMDL Restoration Plans. Some practices in the Stormwater Accounting Guidance give credit for impervious surface reduction but not pollutant reductions because the pollutant reductions are credited to another sector; these additional practices include septic system pumpouts, upgrades, and conversion to sewer (MDE SW 2014). For the *E. coli* portions of the TMDL, best management practice efficiencies from the 2013 Watershed Treatment Model for many of the same stormwater practices are used; these efficiencies are updated when better numbers are available in the literature. The WTM also calculates *E. coli* reductions from management programs like pet waste education and riparian buffer education.

The plan does not currently include estimates from street sweeping or inlet cleaning, despite the fact that the County does implement and track these efforts; the County's protocol does not match MDE's requirements. Future year plan updates should evaluate the potential to modify the County's protocol or work with MDE to obtain credit for these practices. The plan also does not include data from septic pumping because the data are not yet available. Future versions of the plan should also include these data.

The plan includes credits from water quality trading for the Impervious Cover Restoration Plan as described below.

WATER QUALITY TRADING

Maryland Department of the Environment has issued a *Draft Maryland Trading and Offset Policy and Guidance Manual Chesapeake Bay Watershed* (January 2016) and created the Maryland Water Quality Trading Advisory Committee in January 2016 to refine the trading concept. The trading program and policy are under development.

The draft trading policy states that "regulated MS4 jurisdictions are allowed to meet one-half of the impervious area restoration requirement each permit term through trading with point and/or nonpoint sources" and that "point and nonpoint source credits can be acquired at any time during the permit term to meet up to 10 percent of the MS4 jurisdiction's restoration requirement." The County includes this flexibility in the Impervious Cover Restoration Plan within this document.

To convert impervious acres to pollutant load reductions, MDE proposes to use the alternative practice definition from its stormwater accounting guidance (MDE SW 2014), which is the loading difference between forested and untreated impervious urban acres. The table below shows the statewide average loads for impervious and forest for N, P, and TSS. For every acre of imperviousness met through trading, the jurisdiction needs to obtain 12.26 pounds of reduction from nitrogen, 1.62 from phosphorus, and 0.53 from TSS.

Table 6: CBP Pollutant Loads for Impervious and Forest Cover (from MDE 2016)

Parameter	Impervious (lbs/acre/yr)	Forest (lbs/acre/yr)	Delta (lbs/acre/yr)
TN	15.34	3.08	12.26
TP	1.70	0.08	1.62
TSS (tons)	0.56	0.03	0.53
Source: CBWM 5.3.2 Maryland statewide average urban loading rates without BMPs provided by the Science Services Administration (SSA), MDE, 2015.			

The County has worked with other MS4 jurisdictions and wastewater treatment plant owners to propose a point-to-point credit exchange system using wastewater treatment plant performance beyond the 4mg/ml effluent standard, and to allow WWTPs to certify these credits using Discharge Monitoring Reports (DMRs). The County proposes to use performance beyond permit standards from its Ballenger-McKinney Wastewater Treatment Plant in order to take advantage of this flexibility. Preliminary calculations show that an adequate number of credits for this purpose are available. WWTPs can also generate credits for phosphorus and TSS by outperforming standards.

Longer term trades to meet TMDL obligations are not included in this document for TMDL planning at this time. This option is not explored in this document because MDE has not yet proposed such an option, and the volume of credits needed may exceed the credits available. Future plans should consider this option.

ADAPTIVE MANAGEMENT

Frederick County has several assessments currently in progress and will encourage public participation once the final drafts are received. The final drafts of the following assessments are expected in 2016:

- Upper Monocacy Watershed Assessment
- Lower Monocacy Watershed Assessment
- Ballenger Creek Stormwater Master Plan
- Little Hunting Creek Drainage Study

The permit requires yearly updates of this Plan with each Annual report due on December 30th of every year in the current permit.

IMPERVIOUS COVER RESTORATION PLAN

Catoctin Creek Nature Center Green Roof

IMPERVIOUS COVER BASELINE

Section PART IV.E.2.a of the NPDES MS4 Discharge Permit issued by MDE to Frederick County states that "within one year of permit issuance, Frederick County shall submit an impervious surface area assessment consistent with the methods described in the MDE document '*Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated, Guidance for National Pollutant Discharge Elimination System Stormwater Permits*' (MDE, June 2011 or subsequent versions). Upon approval by MDE, this impervious surface area assessment shall serve as the baseline for the restoration efforts required in this permit". Frederick County submitted an Impervious Surface Area Assessment of its MS4 Discharge permit with its first Annual Report under the new permit (December 2015). The Assessment is subject to future refinement by the County based on new or additional information.

MDE, in its Annual Report review, questioned why the County estimated its baseline at 6,725 acres in the previous permit and at 5,063 acres in the current permit. The baseline in the previous permit was derived using the Simple Method by Cappiella and Brown (2001); this method applies impervious cover coefficients to land use land cover (LULC) maps from Maryland Department of Planning. This method is no longer the Best Available Technology and has been replaced by the use of planimetric data, where actual impervious areas are digitized from aerial photography.

MDE also noted in its annual report review that Frederick County did not use the methodology described in its *Basis for Final Determination to Issue Frederick County's National Pollutant Discharge Elimination System, Municipal Separate storm Sewer System Permit (MD0068357 11-DP-3321)*, December 23, 2014. Frederick County asserts that MDE has improperly defined the MS4 boundary in that document. MDE correctly explains the permit coverage in Part I.B of the County's permit, consistent with 40 C.F.R. § 122.26(b)(8) (definition of municipal separate storm sewer),:

> *This permit covers all stormwater discharges from the municipal separate storm sewer system (MS4) owned or operated by Frederick County, Maryland.*

40 CFR 122.26(b)(8) states that:

> *"Municipal separate storm sewer means a conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains):*
>
> *Owned or operated by a State, city, town, borough, county, parish, district, association, or other public body (created by or pursuant to State law) having jurisdiction over disposal of sewage, industrial wastes, storm water, or other wastes, including special districts under State law such as a sewer district, flood control district or drainage district, or similar entity, or an Indian tribe or an authorized Indian tribal organization, or a designated and approved management agency under section 208 of the CWA that discharges to waters of the United States;*
>
> *Designed or used for collecting or conveying storm water;*
>
> *Which is not a combined sewer; and*

> *Which is not part of a Publicly Owned Treatment Works (POTW) as defined at 40 CFR 122.2".*

In its MEP Analysis (2014), the County developed a map of the MS4 service area consistent with this description. The County used an actual map of the storm sewer system and its drainages digitized by the County from development plans and an impervious cover layer derived from planimetrics. This estimate was revised for the first Annual Report (December 2015) submittal deadline to reflect new data including development plan sets, a newly completed impervious cover layer from planimetric data, and an estimate of effectively treated Green Infrastructure (GI) from roof drain disconnects. This latter addition is allowed as a baseline modification in the stormwater accounting guidance (MDE 2014). MDE has recommended that Frederick County assess the areas within its boundary that constitute effectively treated Green Infrastructure, such as open section roads with drainages that meet specifications, and disconnected roof drains within certain specifications. The County's consultant KCI included estimated reductions from roof drain disconnects based on a comparable study completed for Howard County and is developing a task for this effort to validate the number. The County has a study underway with its consultant Dewberry in order to assess open section roads using a protocol developed by the State Highway Administration (SHA). It has not included any estimated reductions in its baseline from this assessment because results from other jurisdictions are not expected to be extrapolable.

To compare the regulatory definition of the MS4 to the definition proposed by MDE Water Management, Frederick County GIS staff, in consultation with the Office of Sustainability and Environmental Resources, developed an impervious cover map in 2014 using MDE requirements from the Draft Fact Sheet. These requirements are later described in MDE's *Basis for Final Determination* (2014). MDE defines the MS4 boundary based on the jurisdictional boundary. Based on the MDE definition of the MS4 boundary in the *Basis for Final Determination*, the amount of restoration needed to meet the 20% retrofit of untreated urban impervious area in the next permit is estimated to be around 1,815 acres. Frederick County's MS4 permit was issued December 30, 2014 and is currently in Frederick Circuit Court, case number 10-C-15-000293. The County's disagreement with MDE on its definition of the MS4 boundary is discussed in the *Final Analysis of Maximum Extent Practicable for the NPDES MS4 Permit Requirements* (MEP 2014) and is included in forthcoming comments on MDE's review of its 2015 Annual Report. Notably, the instructions from MDE on disaggregating TMDLs as described in the TMDL Restoration Plan later in this report rely on yet another definition of the MS4 boundary that the MDE Science Service Administration used to develop TMDL allocations. The 52,159.38 acres attributed to Frederick County's MS4 by MDE's Science Services Administration exceed the actual regulated MS4 acres under the Clean Water Act as well as the acres derived from MDE's *Basis for Final Determination to Issue Frederick County's National Pollutant Discharge Elimination System, Municipal Separate storm Sewer System Permit (MD0068357 11-DP-3321)*, December 23, 2014.

Based on the analysis discussed above, the County has the following within its regulated MS4:

- 6,567: Impervious Acres
  - 5,063: Baseline untreated urban impervious acres
  - 1,504: Controlled Acres (post 2002, controlled to the MEP)
- 1,013: Acres representing 20% of untreated urban impervious area

RESTORATION EFFORTS FOR 20% OF THE COUNTY'S IMPERVIOUS SURFACE AREA

As stated in the previous section, the County estimates its 20% requirement at 1,013 acres. Per MDE, the County must meet half of its restoration goal through the practices described in Part IV.E.2.a of the permit and can meet

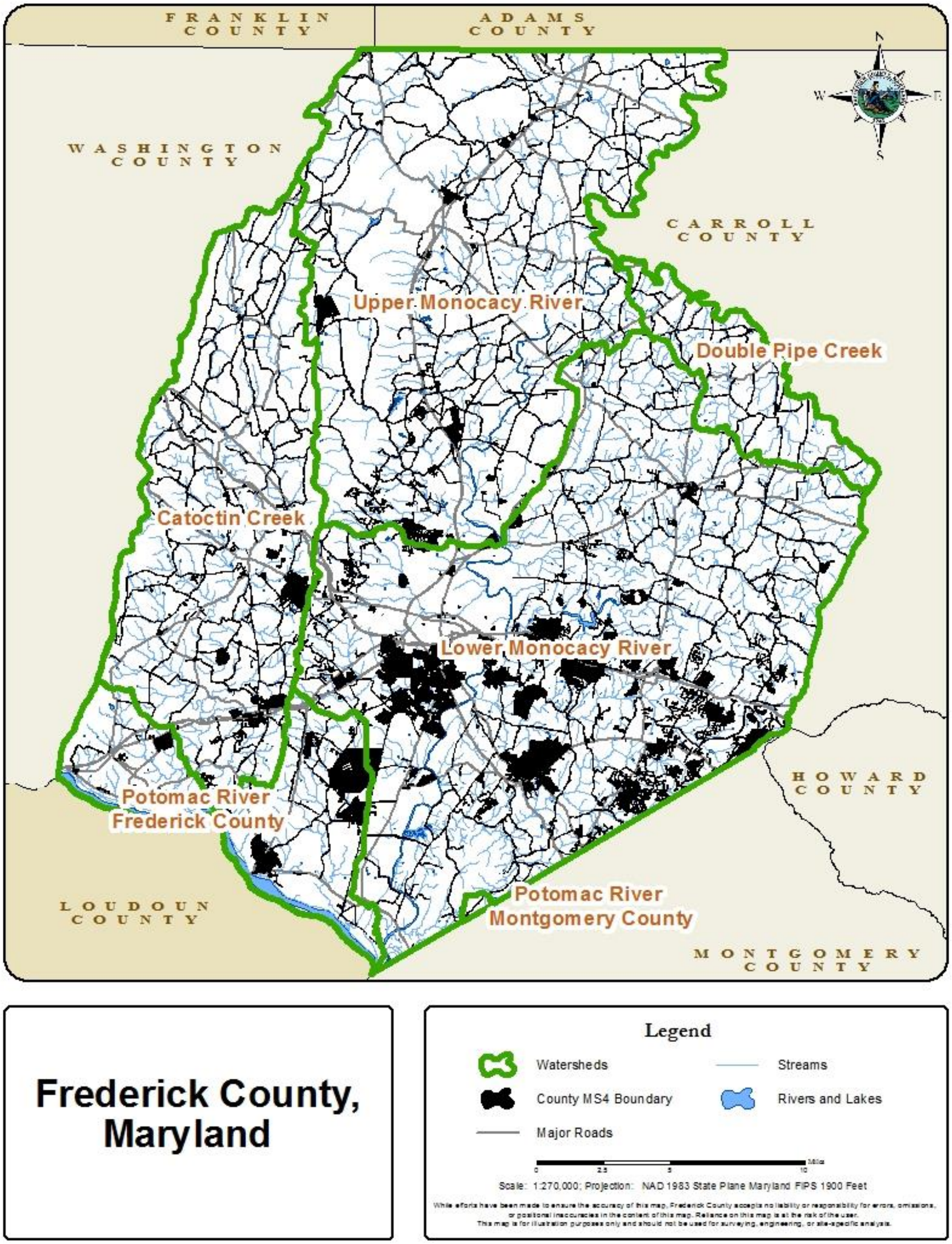


Figure 10: Frederick County's Regulated MS4 Service Area

the other half through trades. Half of the County's goal to treat 20% of the untreated urban impervious surface in the MS4 is estimated to be 506.5 acres. Sources of the 506.5 acres come from two restoration tiers: Completed and Programmed. Restoration projects from the Completed scenario are allowed in the Impervious Cover Restoration Plan per MDE because they were executed after March 11, 2007, the ending date of the previous permit. Programmed projects are allowed because they are scheduled for completion by December 30, 2019, the end date of the current permit. Future scenarios such as Identified and Potential begin after the end date of the current permit and are not included in the Impervious Cover Restoration Plan, though they are essential towards addressing TMDL SW-WLAs.

Figure 11: County Street Sweeper

Despite their use in Frederick County, street sweeping and inlet cleaning best management practice credits are not included at this time because the county's protocol does not match the stormwater accounting guidance (MDE SW 2014).

COMPLETED

Frederick County is counting 160.5 acres of completed projects towards its impervious area restoration. A project-by-project list for the Completed Scenario is included in Appendix 1. The following tables summarizes the acres of completed projects by type and by site and type for all Completed projects in the county, plus septic projects. See the Restoration Tiers section for definitions of each tier. Note that the BMP Types are from MDE's geodatabase and are explained in the Acronyms section.

Table 7: Completed Project Impervious Acres by BMP Type

BMP Type	Imp Acres
BIO	2.8
ESDRG	0.3
ESDSW	0.3
FPU	43.0
PP	0.1
SEPC	2.7
SEPD	47.8
STRE	23.4
WP	40.2
Grand Total	**160.5**

Table 8: Completed Project Impervious Acres by Site and BMP Type

Site and BMP Type	Imp Acres
Ballenger Creek Elementary School	**0.6**
FPU	0.6

Ballenger Creek Stream Rest	**6.1**
STRE	6.1
Brunswick High School	**0.4**
FPU	0.4
Catoctin Mountain Park	**2.3**
FPU	2.2
GMB	0.0
PP	0.1
Citizens Care and Rehab	**25.2**
WP	25.2
Cloverhill	**0.5**
FPU	0.5
Cooperative Extension Building	**0.3**
ESDRG	0.3
Crestwood Middle School	**0.8**
FPU	0.8
Cunningham Fall State Park	**0.0**
FPU	0.0
Deer Crossing Elementary School	**1.1**
FPU	1.1
Emmitsburg Elementary School	**0.0**
FPU	0.0
Englandtowne Stream Rest	**7.3**
STRE	7.3
Fred Archibald Santuary	**2.6**
FPU	2.6
GTJ Middle School	**0.0**
FPU	0.0
Holly Hills Country Club	**5.8**
FPU	5.8
Holly Hills HOA	**0.4**
FPU	0.4
Kemptown Elementary School	**0.0**
FPU	0.0
Liberty Village	**0.7**
FPU	0.7
Libertytown Park	**1.6**
FPU	1.6
Middletown High School	**0.2**
FPU	0.2

Monocacy Elementary School	**0.0**
FPU	0.0
Monocacy National Battlefield	**5.0**
FPU	5.0
Mountain Village HOA	**1.2**
FPU	1.2
Mt. Airy East West Park	**1.4**
FPU	1.4
Mt. Airy Village Gate Park	**1.0**
FPU	1.0
Mt. Airy Windy Ridge Park	**0.0**
FPU	0.0
Mt. Saint Mary's Run	**0.0**
FPU	0.0
New Forest Society Nursery	**0.0**
FPU	0.0
New Market Middle School	**1.2**
FPU	1.2
Oakdale Elementary School	**0.0**
FPU	0.0
Old National Pike Park	**1.8**
FPU	1.8
Orchard Grove Elementary School	**0.3**
FPU	0.3
Parkway Elementary School	**0.0**
FPU	0.0
Pinecliff Park	**0.8**
FPU	0.8
Pinecliff Park Stream Rest	**10.0**
STRE	10.0
Public Safety Training Facility	**15.0**
WP	15.0
Rivermist Park	**0.0**
FPU	0.0
Septic Connections to WWTP	**2.7**
SEPC	2.7
Septic Denitrification (BRF)	**47.8**
SEPD	47.8
Septic Pumping	**0.0**
SEPP	0.0

Spring Ridge Elementary School	**1.1**
FPU	1.1
St. Peter the Apostle Church	**0.2**
FPU	0.2
Street Sweeping	**0.0**
MSS	0.0
Tuscarora Elementary School	**0.0**
FPU	0.0
Urbana Community Park	**1.2**
ESDSW	0.3
FPU	0.9
Urbana Elementary School	**0.1**
ESDSW	0.0
FPU	0.1
Urbana High School	**0.0**
FPU	0.0
Urbana High School Retrofit	**2.8**
BIO	2.8
Urbana Middle School	**0.5**
FPU	0.5
Utica Park	**0.3**
FPU	0.3
Valley Elementary School	**0.8**
FPU	0.8
Walkersville Community Park	**0.0**
FPU	0.0
Walkersville High and Elem	**0.0**
FPU	0.0
West Frederick Middle	**0.0**
FPU	0.0
Windsor Knolls Elementary	**4.7**
FPU	4.7
Windsor Knolls Middle School	**4.6**
FPU	4.6
Wolfsville Elementary	**0.4**
FPU	0.4
Woodsboro Community Park	**0.0**
FPU	0.0
Woodsboro Elementary School	**0.0**
FPU	0.0

Worthington Manor Golf Course	**0.0**
FPU	0.0
Grand Total	**160.5**

PROGRAMMED

A project list for the Programmed Scenario is included in Appendix 2. The following table summarizes the acres of completed projects by type for all Programmed projects in the county. See the Restoration Tiers section for definitions of each tier.

Table 9: Programmed Project Impervious Acres by BMP Type

BMP Type	Sum of Imp Acres
BR	10.56
EDSW	207.19
FPU	185.09
IB	4.61
IMPF	1.3
PPKTSF	1.38
Proposed trading program	255.8
SDV	0
SEPD	57.6
STRE	98.55
VSS	0
WP	18.16
WSHW	12.21
Grand Total	**852.45**

CONCLUSION

The Impervious Cover Restoration Plan in this document plans for the permit requirement to restore 20% of the County's untreated urban impervious area (area where water can not percolate) using best management practices for stormwater. The County has an estimated 5,063 untreated urban impervious acres estimated in its impervious cover baseline. 20% of this number is 1,013 acres. At least half of this number, or 506.5 acres, must be met through restoration projects approved in MDE's stormwater accounting guidance (2014). The County has completed 160.5 acres of restoration towards its impervious cover restoration requirements, and has an additional 852.5 acres programmed. The County anticipates completing 757.2 acres of physical restoration towards the MS4 permit requirement by the end of the permit cycle on December 30, 2019. Per MDE, the remainder can be met through credit exchanges in its nascent trading program. The details of this program are evolving. The County can address the remaining impervious surface restoration obligation of 255.8 acres through such trades. If restoration projects have scheduling problems due to permits or other unforeseen circumstances, the County reserves the right to use up to 506.5 acres from trading, commensurate with half of the 20% restoration requirement.

The County is on track to meet its impervious cover restoration requirement of 1,013 acres.

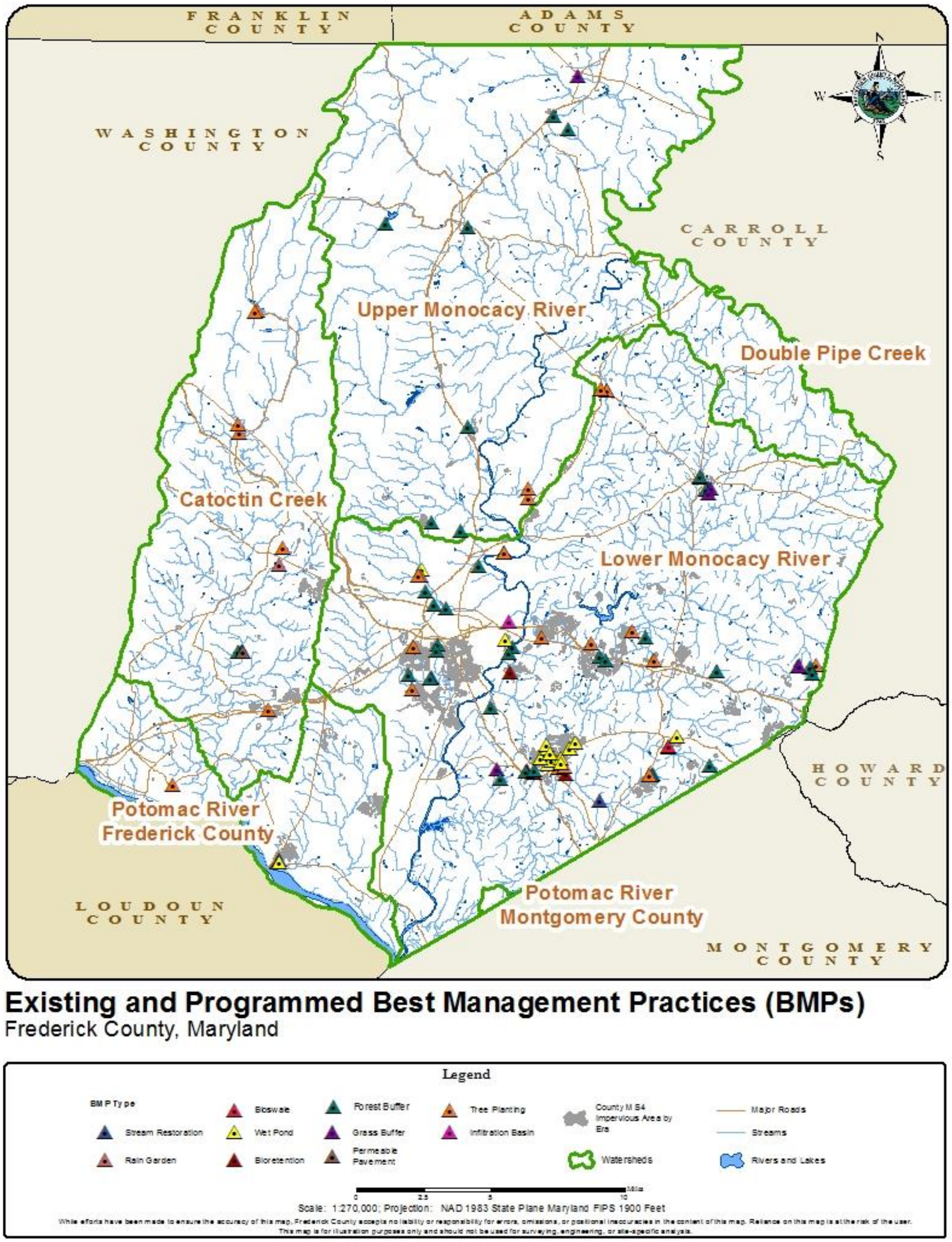


Figure 12: Completed and Programmed BMPs

Windsor Knolls Middle School Tree Planting and Wetland Enhancement

OVERVIEW

Nutrient and sediment surface water pollution causes eutrophication of our local waterways as well as the Chesapeake Bay; this eutrophication results in lower dissolved oxygen content, greater turbidity, displaced native organisms, greater or lesser pH, and many other environmental effects that depreciate habitat quality. Degraded habitats cause a negative impact on biodiversity, which then causes an imbalance in the ecosystem and removes many ecosystem services provided by those organisms. Ecosystem services such as recycling nutrients deposited from our agricultural croplands specifically rely on a diverse collection of healthy species populations. Rich biodiversity keeps all trophic levels intact, assuring our economic fisheries and research organisms remain healthy enough for harvest. Sources of nutrient and sediment impairment have been identified by many different organizations; the contribution of impairment from each source must be quantified and then reduced by implementation of proper BMPs.

SOURCES OF IMPAIRMENT

NITROGEN

Commonly a limiting nutrient in salt water systems, organisms in both fresh and salt water systems grow most effectively when the soluble nitrogen is found in a ratio of 16:1 relative to phosphorus concentration. Although nitrogen is the limiting nutrient in salt water systems, the Chesapeake Bay is limited by both nitrogen and phosphorus (differing by region of the bay). When applied to soils, nitrogen binds to the macropores; this biochemistry causes nitrogen to be more susceptible to leaching. This means that during storm events, nitrogen peaks are observed in our waterways. These nutrient peaks cause an increased growth of algal blooms, which limit the sunlight and dissolved oxygen available for all other organisms. These leaching events also demand nitrogen to be applied more frequently to agricultural soils in order to maintain desired crop yields. These two facts about nitrogen require greater and more efficient restoration efforts in order to reach the nitrogen TMDL.

Sources of nitrogen impairment to our waterways include: agricultural cropland fertilizers, residential lawn fertilizers, atmospheric deposition, sewer overflows, industrial point-source discharges, construction runoff and erosion, wastewater, sewage, sludge, and hazardous waste land disposals, municipal wastewater disposal, natural mineral and metal deposits, herbicides, insecticides, acid mine drainage, pet wastes, livestock wastes, petroleum product runoffs, faulty gasoline tanks, and all urban runoff materials (tires shreds, asphalt, and littered trash materials) (EPA Nit). Implementing biological infrastructure best management practices, reducing excess nitrogen application, utilizing natural sources of fertilizer (i.e. watermeal, wetlands, livestock and human wastes, etc.), and reducing nitrogen content in from our point source effluents will effectively reduce nitrogen loadings toward the Frederick County nitrogen TMDL.

PHOSPHORUS

While nitrogen binds to macropores, phosphorus binds more tightly within soil micropores; leaving it less susceptible to leaching and more associated with sediment depositions. Phosphorus, then, needs to be applied less frequently than nitrogen and has a positive correlation with sediment impairments. This means that freshwater systems, and phosphorus-limited bay regions, can expect greater phosphorus related algal growth during times of heavy sediment transport. Work towards reaching our sediment TMDL will also help reduce the phosphorus loads, and vice versa. Phosphorus binding more tightly to soils may have its benefits, however, it also outlines the fact that phosphorus experiences stronger and more prolonged delays. Loads will take longer to reach our surface water systems, making it more difficult to estimate phosphorus loadings until we observe more long-term load data. Nitrogen and phosphorus also experience delayed loading due to groundwater nutrient loading, it takes a few decades for all nutrient runoff from groundwater to reach the Chesapeake.

Sources of phosphorus impairment include: all sources listed for nitrogen as well as some soaps and detergents (United States outlawed use of phosphorus compounds in many soaps, shampoos, etc.), stream bank erosion, erosion from construction, and all other sources of sediment erosion.

SEDIMENT

Sediment impairment is recognized as one of the most important pollutants to control because it carries many other harmful substances, such as PCBs, bacteria, and minerals that effect pH (just to list a few). When we discuss sediment as a pollutant in our surface waters, we are mainly referring to Suspended Solids (SS). The EPA defines SS as mainly inorganic particles consisting of clay and silt the size of less than 0.063 mm to sizes between 0.063 mm and 0.250 mm (EPA SS). While nitrogen and phosphorus contribute to eutrophication via providing food for algal growth, sediment contributes to surface water health depreciation by increasing the streambed levels, effectively decreasing the overall ratio of water volume to living organisms. Sediment transport and deposition also covers bottom-dwelling organisms and makes it more difficult for smaller organisms to feed as well as filter water through their gas exchange apparatuses. These damages to the organisms' habitat and physiology cause native species to struggle, promoting the colonization of introduced species.

Stormwater sources of sediment impairment, according to the EPA, include: de-vegetated banks or shores, logging roads and trails, construction, road maintenance, landslides, erosional rills and gullies, stored soil or waste, in-stream gravel mining, vehicle or boat traffic, breached impoundments, incised channels, channel modification, eroding and collapsing stream banks, shallow or poorly developed root systems, impoundments, upstream scoured stream beds, impervious surfaces, and lack of connectivity with flood plain (EPA SS). Stream bank stabilization and stream restoration best management practices are known to be the most effective practices for reducing sediment load in surface waters.

CHESAPEAKE BAY (FREDERICK COUNTY) TMDL PLANS BY WATERSHED

The Chesapeake Bay TMDLs, established by the EPA (EPA, 2010), set pollution limits for nitrogen, phosphorus, and sediment in the Chesapeake Bay Watershed. These TMDLs, required under the Clean Water Act, were in response to the slow progress by states within the watershed to limit their pollutants to levels which meet water quality standards in the Bay and its tidal tributaries. Total limits set in the Bay TMDL for the states of Delaware, Maryland, New York, Pennsylvania, Virginia, West Virginia, and the District of Columbia are "185.9 million pounds of nitrogen, 12.5 million pounds of phosphorus and 6.45 billion pounds of sediment per year—a 25 percent reduction in nitrogen, 24 percent reduction in phosphorus and 20 percent reduction in sediment" (EPA 2010). The TMDL also sets "rigorous accountability measures" for state compliance.

While not a requirement in the County's MS4 permit, restoration strategies to meet local TMDL reduction targets and impervious restoration treatment were also modeled against the Bay TMDL goals in order to calculate progress. The County's MS4 permit is requiring compliance with the Chesapeake Bay TMDL through the use of the 20% impervious surface treatment strategy as described in greater detail in the following section.

Figure 13: Watersheds in Frederick County Subject to Chesapeake Bay TMDLs for Nitrogen and Phosphorus

SW-WLAS AND CALIBRATION

Table 10 provides a concise summary of Frederick County's portions of target edge of stream (EOS) and delivered (DEL) reductions towards the Chesapeake Bay TMDL and 2010 baseline and 2025 allocated loads.

- **TN, TP, TSS:** Total Nitrogen, Total Phosphorus, Total Suspended Sediment. As specified in the Bay TMDL, if the phosphorus target is met, the sediment target will be met.
- **EOS lbs/yr and DEL lbs/yr:** An EOS load is the amount of a pollutant load that is transported from a source to the nearest stream annually while a DEL load is the amount of a pollutant load that is transported to the tidal waters of the Chesapeake Bay annually. DEL loads are generally less than EOS loads due to losses during transport from streams to the Bay.
- **Calibrated 2010 Baseline Load**: Baseline levels (i.e., land use loads with baseline BMPs) from 2010 conditions in the Frederick County MS4 source sector using the Maryland Assessment Scenario Tool (MAST) Chesapeake Bay Program Phase 5.3.2 (CBP P5.3.2) model. Baseline loads were used to calibrate the Bay TMDL nitrogen and phosphorus SW-WLAs.
- **Target Percent Reduction**: Percent reductions assigned to Frederick County Phase I MS4 stormwater sector (http://wlat.mde.state.md.us/ByMS4.aspx). If TP target is met, TSS target will be met.
- **Calibrated Target Reduction:** Target reduction calibrated to MAST CBP v.5.3.2 by multiplying the reduction percent published by the 2010 baseline load. If TP target is met, TSS target will be met.
- **Calibrated TMDL WLA**: Allocated loads are calculated from the 2010 baseline levels, calibrated to CBP P5.3.2 as noted above, using the following calculation: 2010 Baseline – (2010 Baseline x Target Percent Reduction); or, 2010 Baseline x (1 – Target Percent Reduction).

Table 10 - Frederick County Chesapeake Bay TMDL Baseline and Target Loads

Baseline and Target	TN-EOS lbs/yr	TN-DEL lbs/yr	TP-EOS lbs/yr	TP-DEL lbs/yr	TSS-EOS lbs/yr	TSS-DEL lbs/yr
Calibrated 2010 Baseline Load	1,096,458.45	556,694.68	46,994.58	22,046.67		
Target Percent Reduction	10.2%	10.9%	20.7%	20.7%	-	-
Calibrated Target Reduction	111,838.76	60,679.72	9,727.88	4,563.66	-	-
Calibrated Bay TMDL WLA	984,619.69	496,015.00	37,266.70	17,483.01	-	-

NITROGEN TMDL

The Baseline year for the Chesapeake Bay Nitrogen TMDL was 2010. The TMDL requires a 10.9% reduction from baseline, which amounts to a reduction of 60,679.72 pounds delivered to the Bay.

Table 11: Baseline by Subwatershed and Reduction for Chesapeake Bay Nitrogen TMDL

Row Labels	Sum of Acres	Sum of NLoadEOS	Sum of NLoadDEL
Catoctin Creek	**7653.64**	**177197.05**	**57798.98**
County Phase I/II MS4 Impervious	1300.95	38342.43	11422.76
County Phase I/II MS4 Pervious	6352.69	138854.62	46376.22
Double Pipe Creek	**1427.22**	**30387.6**	**7554.76**

County Phase I/II MS4 Impervious	240.86	6903.27	1728.42
County Phase I/II MS4 Pervious	1186.36	23484.33	5826.34
Lower Monocacy River	**31835.76**	**649764.05**	**366146.58**
County Phase I/II MS4 Impervious	5715.73	150966.65	86323.91
County Phase I/II MS4 Pervious	26120.03	498797.4	279822.67
Potomac River FR Cnty	**3656.79**	**78001.66**	**57482.75**
County Phase I/II MS4 Impervious	697.71	19253.45	14203.87
County Phase I/II MS4 Pervious	2959.08	58748.21	43278.88
Potomac River MO Cnty	**53**	**1144.09**	**886.3**
County Phase I/II MS4 Impervious	9	260.71	201.96
County Phase I/II MS4 Pervious	44	883.38	684.34
Upper Monocacy River	**7532.97**	**159964**	**66825.31**
County Phase I/II MS4 Impervious	879.19	25452.18	10193.27
County Phase I/II MS4 Pervious	6653.78	134511.82	56632.04
Grand Total	**52159.38**	**1096458.45**	**556694.68**
Reduction %			10.9%
Calibrated Reduction			60,679.72
Calibrated WLA			496,015.00

Chesapeake Bay nitrogen scenarios are in Appendix 14.

Table 12: Reductions by Scenario for Chesapeake Bay Nitrogen TMDL

Scenario	Scenario Reduction lbs/yr	Cum Redn lbs/yr	Load lbs/yr	% Redn
Baseline	0	0.00	556,694.68	0.0%
Completed	552.39	552.39	556,142.29	0.9%
Programmed	2,667.80	3,220.19	553,474.49	5.3%
Identified	14,259.90	17,480.09	539,214.59	28.8%
Potential	43,213.05	60,693.14	496,001.54	100.0%
Calculated Disaggregated County MS4 Redn	60,679.72			

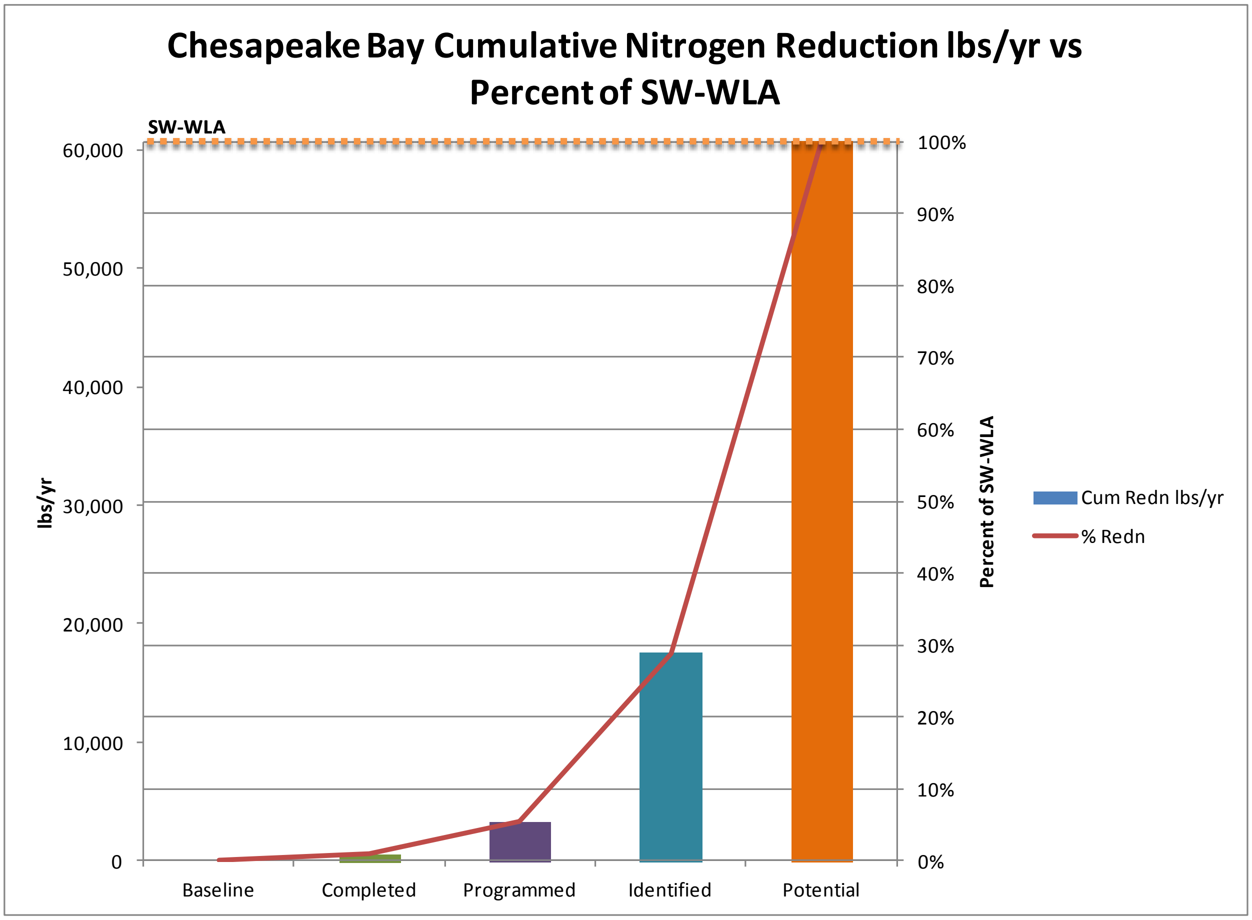


Figure 14: Chesapeake Bay Cumulative Nitrogen Reductions lbs/yr vs. Percent of SW-WLA

The Chesapeake Bay TMDL for nitrogen includes all best management practices required to meet all other Frederick County TMDLs with the exception of some programmatic BMPs for *E. coli*. For this reason the Chesapeake Bay TMDL Restoration Plan for Nitrogen governs the schedules and costs for all other TMDLs. The following reductions are achieved by subwatershed under the Chesapeake Bay TMDL Restoration Plan for Nitrogen:

Table 13: Edge of Stream and Delivered loads in Chesapeake Bay Nitrogen TMDL Restoration Plan

Segment	Acres	N Load EOS	N Load DEL	P Load EOS	P Load DEL	S Load EOS	S Load DEL
Catoctin Creek	7653.64	167072	54504.11	4975.96	2334.39	3173334.28	2055982.09
Double Pipe Creek	1427.22	29717.89	7387.7	1008.94	473.33	573474.29	371550.14
Lower Monocacy River	31835.76	555804.52	313074.87	10562.94	4955.43	2632748.7	1705740.28
Potomac River FR Cnty	3656.79	76127.69	56101.74	3022.12	1417.77	1329669.91	861484.23
Potomac River MO Cnty	53	1144.09	886.3	51.1	23.97	19422.4	12583.64
Upper Monocacy River	7532.97	153151.39	64046.82	3849.06	1805.72	1534041.09	993894.94
Grand Total	52159.38	983017.58	496001.54	23470.12	11010.61	9262690.67	6001235.32

PHOSPHORUS TMDL

The Baseline year for the Chesapeake Bay Phosphorus TMDL was 2010. The TMDL requires a 10.9% reduction from baseline, which amounts to 4,563.66 pounds delivered to the Bay.

Table 14: Baseline by Subwatershed and Reduction for Chesapeake Bay Phosphorus TMDL

Row Labels	Sum of Acres	Sum of PLoadEOS	Sum of PLoadDEL
Catoctin Creek	**7653.64**	**7793.8**	**3656.33**
County Phase I/II MS4 Impervious	1300.95	3902.74	1830.91
County Phase I/II MS4 Pervious	6352.69	3891.06	1825.42
Double Pipe Creek	**1427.22**	**1350.35**	**633.49**
County Phase I/II MS4 Impervious	240.86	685.9	321.78
County Phase I/II MS4 Pervious	1186.36	664.45	311.71
Lower Monocacy River	**31835.76**	**28023.31**	**13146.66**
County Phase I/II MS4 Impervious	5715.73	14344.52	6729.49
County Phase I/II MS4 Pervious	26120.03	13678.79	6417.17
Potomac River FR Cnty	**3656.79**	**3422.87**	**1605.76**
County Phase I/II MS4 Impervious	697.71	1853.75	869.65
County Phase I/II MS4 Pervious	2959.08	1569.12	736.11
Potomac River MO Cnty	**53**	**51.1**	**23.97**
County Phase I/II MS4 Impervious	9	25.94	12.17
County Phase I/II MS4 Pervious	44	25.16	11.8
Upper Monocacy River	**7532.97**	**6353.15**	**2980.46**
County Phase I/II MS4 Impervious	879.19	2557.21	1199.67
County Phase I/II MS4 Pervious	6653.78	3795.94	1780.79
Grand Total	**52159.38**	**46994.58**	**22046.67**
Reduction %			20.7%
Calibrated Reduction			4,563.66
Calibrated WLA			17,483.01

Chesapeake Bay phosphorus scenarios are in Appendix 15.

Table 15: Reductions by Scenario for Chesapeake Bay Phosphorus TMDL

Scenario	Scenario Reduction lbs/yr	Cum Redn lbs/yr	Load lbs/yr	% Redn
Baseline	0	0.00	22,046.67	0.0%
Completed	71.26	71.26	21,975.41	1.6%
Programmed	324.08	395.34	21,651.33	8.7%
Identified	1,792.45	2,187.79	19,858.88	47.9%
Potential	8,848.27	11,036.06	11,010.61	241.8%
Calculated Disaggregated County MS4 Redn	4,563.66			

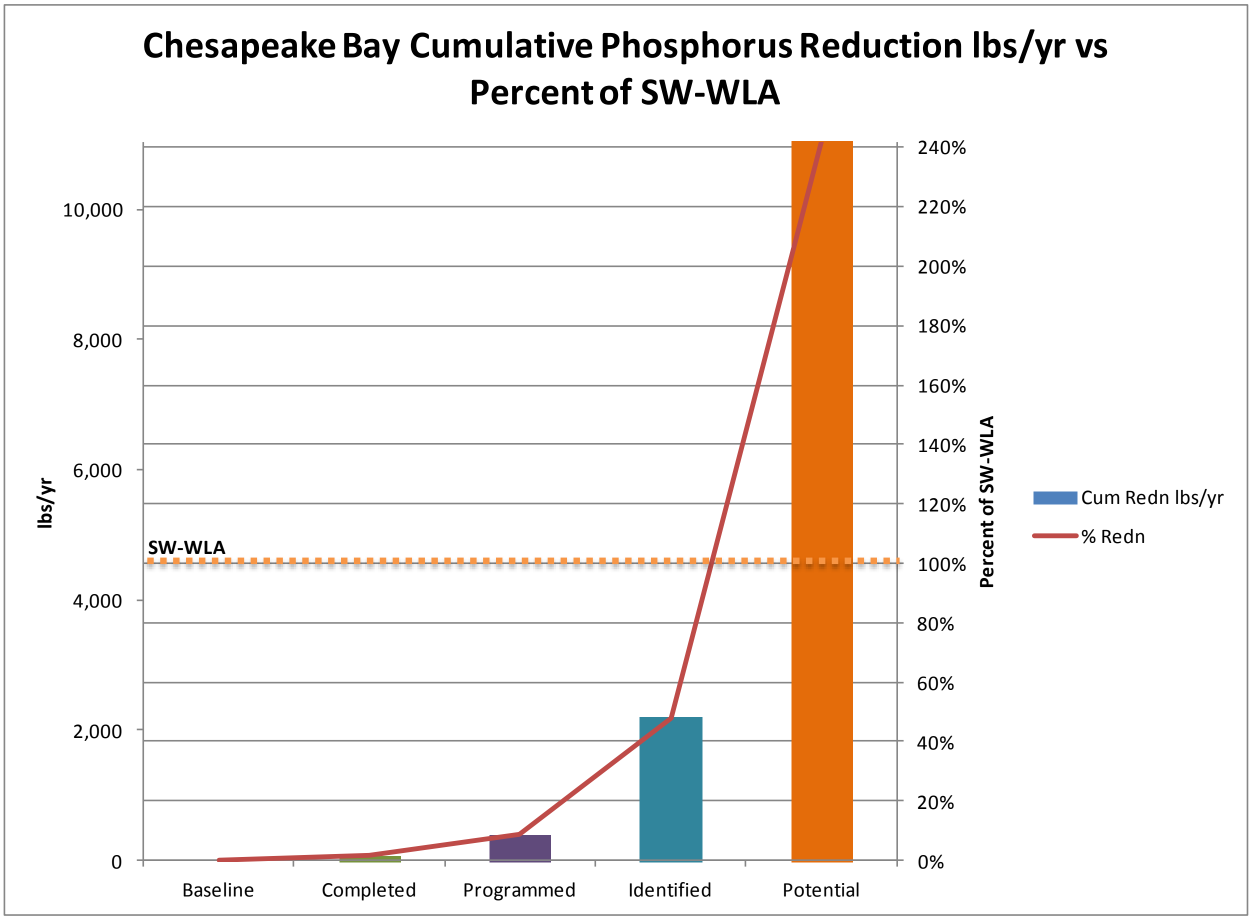


Figure 15: Chesapeake Bay Cumulative Phosphorus Reductions lbs/yr vs. Percent of SW-WLA

LOCAL NUTRIENT AND SEDIMENT PLANS BY WATERSHED

As a requirement of PART IV.E.2.b of the Permit, issued by MDE to Frederick County, the County must develop restoration plans for each stormwater wasteload allocation (SW-WLA) approved by the Environmental Protection Agency (EPA) prior to the effective date of the permit. This applies to all current local TMDLs as well as any new TMDLs approved by EPA. There are currently 12 final approved TMDLs within Frederick County with either an individual or aggregate SW-WLA, shown in the table below.

Table 16 - Frederick County Local TMDLs with SW-WLAs

Segment	Impairment	Allocation Type	Baseline Year
Catoctin Creek	Phosphorus	Individual	2009
Catoctin Creek	Sediment	Aggregate	2000
Double Pipe Creek	Phosphorus	Individual	2009
Double Pipe Creek	Sediment	Aggregate	2000
Double Pipe Creek	*Escherichia coli*	Aggregate	2004
Lower Monocacy River	Phosphorus	Individual	2009
Lower Monocacy River	Sediment	Aggregate	2000
Lower Monocacy River	*Escherichia coli*	Aggregate	2004
Potomac River Montgomery County	Sediment	Individual	2005

Upper Monocacy River	Phosphorus	Individual	2009
Upper Monocacy River	Sediment	Aggregate	2000
Upper Monocacy River	*Escherichia coli*	Aggregate	2004

In order to derive the County MS4-specific SW-WLA load reduction targets, MDE's published baseline values for each TMDL need to be *disaggregated* and *calibrated* before the percent reduction is applied to calculate the load reduction required. The two procedures are described below.

DISAGGREGATION

Some SW-WLAs are developed by MDE as an aggregate load including load contributions from multiple jurisdictions. Aggregate values must be first disaggregated to determine the portion of the load that each jurisdiction is responsible for. To date, Frederick County is responsible for seven aggregate WLAs and five individual WLAs. There are two methods used in the annual report for disaggregating loads; the first method uses the proportion of County urban land to total urban land in the watershed to partition out the County's baseline load. The second disaggregation method uses the BayFAST (Bay Facility Assessment Scenario Tool) model to calculate the baseline load.

CALIBRATION

Frederick County's TMDLs were developed by MDE at different periods in time using a variety of models. In order to use current models such as MAST (Maryland Assessment Scenario Tool), which is based on the current version of the Chesapeake Bay Model (v5.3.2), for analysis of load reductions, the baseline load needs to be translated or "calibrated" from the model used to develop the TMDL to the current model. According to the MDE guidance document *Guidance for Using the Maryland Assessment Scenario Tool to Develop Stormwater Wasteload Allocation Implementation Plans for Local Nitrogen, Phosphorus, and Sediment TMDLs* (MDE MAST 2014), Section I, baseline nutrient and sediment loads and SW-WLAs must be calibrated to the model used to calculate load reductions:

Because all of Maryland's approved local nutrient and sediment TMDLs were developed using watershed models other than MAST [Maryland Assessment Scenario Tool], the baseline and target loads from these TMDLs need to be translated into MAST loadings. This adjustment is required to account for potential differences between models. This is a two-step process that involves 1) creating a MAST scenario that replicates the baseline year of the TMDL, and 2) applying the load reduction percentage from the TMDL to the MAST loading for the baseline year.

DISAGGREGATING BACTERIA BASELINE LOADS

Bacteria load reductions are not modeled using BayFAST or MAST, therefore aggregate bacteria SW-WLAs were disaggregated but did not require calibration. The aggregate SW-WLA for the County's bacteria TMDLs were disaggregated following steps outlined in MDE's guidance for Bacteria TMDLs (MDE Bacteria 2014). In order to determine Frederick County's portion of the load, the aggregate SW-WLA must be disaggregated based on the percentage of Frederick County's MS4 regulated urban land area within the TMDL watershed. The proportion of Frederick County MS4 urban land area to total urban land area, including other jurisdictions, within the 8-digit watershed boundaries was calculated. Urban land use categories from Maryland Department of Planning 2010 land use data (MDP, 2010) were used to define each jurisdiction's urban area. The percentage of Frederick County MS4 urban land area was then applied to the aggregate SW-WLA published in the local TMDL document. Local

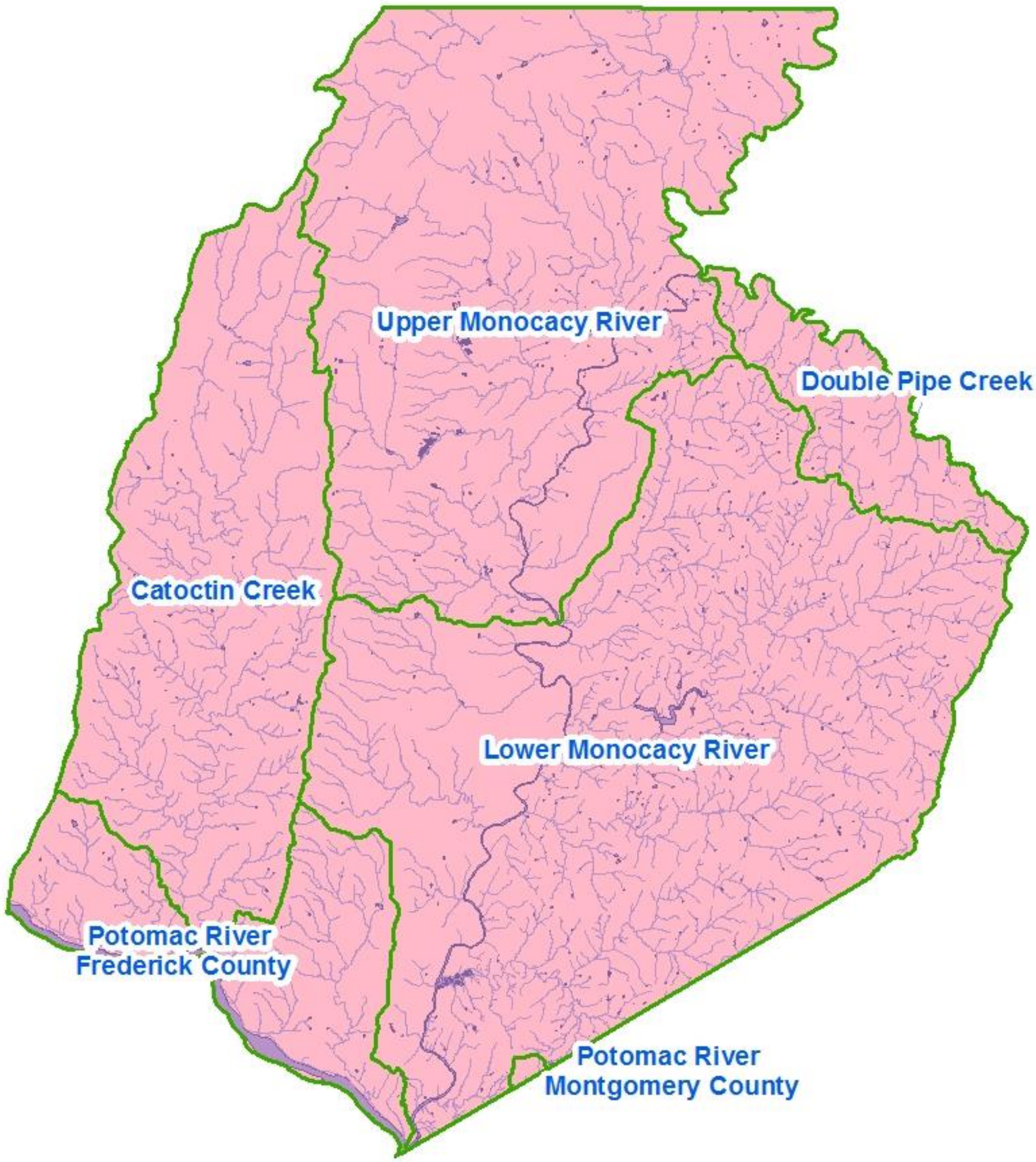


Figure 16: Watersheds with Local Sediment TMDLs (All)

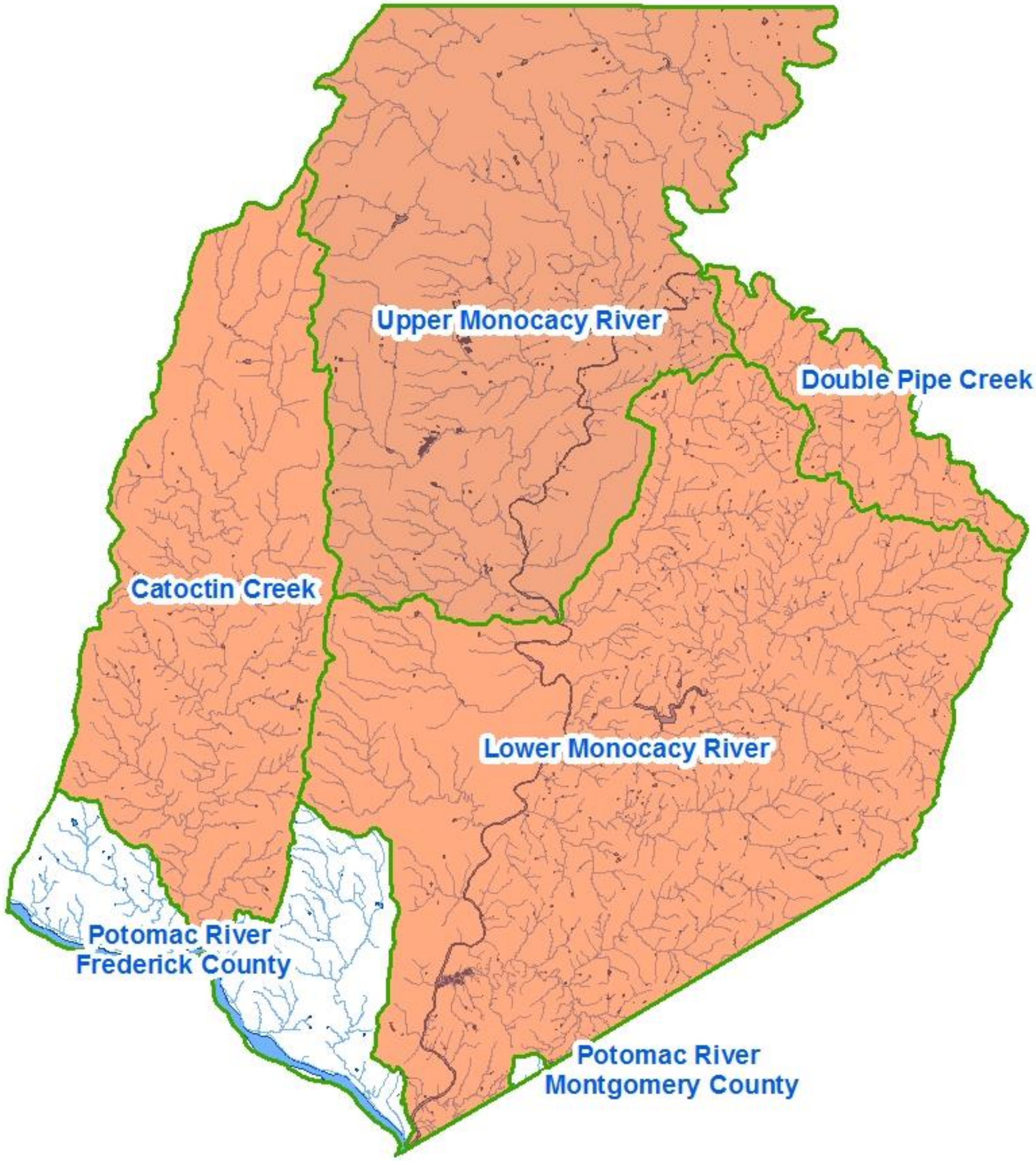


Figure 17: Watersheds with Local Phosphorus TMDLs

TMDLs with individual SW-WLAs require a specified percent reduction of pollutant loads from baseline levels to achieve the target SW-WLA and no disaggregation is necessary. Table 17 displays Frederick County local TMDLs with SW-WLAs disaggregated.

The load reductions calculated from disaggregating the aggregate bacteria SW-WLAs following MDE guidance stated above will be the target used for TMDL compliance. These values are presented in bold in the Calculated Disaggregated County MS4 Reduction column of Table 17.

USING BAYFAST TO DISAGGREGATE AND CALIBRATE NUTRIENT AND SEDIMENT LOADS

Local TMDL baseline loads for nutrients and sediments were disaggregated and calibrated in BayFAST. BayFAST allows users to specify the watershed and jurisdiction to model; therefore, the results include only Frederick County MS4 baseline loads and do not include other municipalities. The results then represent the disaggregated portion of the baseline load.

The baseline model includes County BMPs installed prior to the TMDL baseline year on top of baseline land use background loads. BayFAST functions similarly to MAST; however, BayFAST allows users to delineate facility boundaries (e.g., watershed, parcel, drainage area) and alter land use information within the delineated boundary depending on the model year. The general calibration procedure is as follows:

1. For each local TMDL, a facility boundary for the 8-digit TMDL watershed within Frederick County borders was delineated within BayFAST.
2. All default land use acreages were deleted and regulated pervious and impervious acres were replaced with MAST Local Base County Phase I MS4 urban pervious and impervious acres using the Compare Scenario tool in MAST for the respective baseline year for each local TMDL. This approach inherently disaggregates County MS4 loads from the rest of the NPDES regulated area within the watershed.
3. County BMPs installed prior to the TMDL baseline year were then added to the model.
4. The reduction percentage published in the TMDL document was then applied to the calibrated baseline loads modeled in BayFAST to calculate a calibrated reduction in EOS-lbs/yr.
5. A calibrated SW-WLA was calculated by subtracting the calibrated reduction from the BayFAST baseline load.

Table 18 displays Frederick County nutrient and sediment local TMDLs with baseline loads and SW-WLAs calibrated to BayFAST.

Calibrated load reductions calculated based on TMDL percent reductions and baseline loads modeled in BayFAST using Frederick County Phase I MS4 baseline pervious and impervious land use and baseline treatment will be the target reductions used for TMDL compliance for nutrient and sediment local TMDLs. These values are presented in bold in the Calibrated Reduction column of Table 18.

Table 17: Frederick County Local TMDLs with SW-WLAs. Aggregate SW-WLAs Disaggregated Following MDE Guidance

Watershed Name	Watershed Number	WLA Type	Baseline Year	Baseline Model[1]	Pollutant	Units	MDE Published WLA[2]	MDE Published Reduction %[2]	8-digit Watershed Frederick County MS4 Urban Land Area (ac)[3]	8-digit Watershed TOTAL NPDES Land Area (ac)[4]	% of County MS4 Land Area[5]	Calculated Disaggregated County MS4 WLA[6]	Calculated Disaggregated County MS4 Reduction[7]	Calculated Disaggregated County MS4 Baseline Load[8]
Catoctin Creek	02140305	Individual	2009	CBP WM P5.3.2	Phosphorus	Lbs/yr	7,374.0	11.0%	-	-	-	-	-	-
		Aggregate	2000	CBP WM P5	Sediment	Tons/yr	1,392.0	49.1%	16,823.1	18,729.6	90%	1,250.3	1,206.1	2,456.4
Double Pipe Creek	02140304	Individual	2009	CBP WM P5.3.2	Phosphorus	Lbs/yr	301.0	73.0%	-	-	-	-	-	-
		Aggregate	2000	CBP WM P5	Sediment	Tons/yr	228.9	46.8%	2,042.0	24,612.0	8%	19.0	16.7	35.7
		Aggregate	2004	N/A	*E. coli*	Billion MPN/yr	23,884.0	98.8%				1,981.6	**163,151.1**	165,132.7
Lower Monocacy River[9,10]	02140302	Individual	2009	CBP WM P5.3.2	Phosphorus	Lbs/yr	22,766.0	28.0%	-	-	-	-	-	-
		Aggregate	2000	CBP WM P5	Sediment	Tons/yr	3,157.9	60.8%	40,336.0	58,149.5	69%	2,190.5	3,397.5	5,588.0
		Aggregate	2004	N/A	*E. coli*	Billion MPN/yr	183,893.0	92.5%				127,559.2	**1,573,230.4**	1,700,789.7
Potomac River Montgomery County	02140202	Individual	2005	CBP WM P5.2	Sediment	Tons/yr	1.5	36.2%	-	-	-	-	-	-
Upper Monocacy River	02140303	Individual	2009	CBP WM P5.3.2	Phosphorus	Lbs/yr	7,131.0	4.0%	-	-	-	-	-	-
		Aggregate	2000	CBP WM P5	Sediment	Tons/yr	1,770.0	49.0%	17,519.6	25,548.6	69%	1,213.8	1,166.2	2,379.9
		Aggregate	2004	N/A	*E. coli*	Billion MPN/yr	37,961.0	97.0%				26,031.3	**841,679.4**	867,710.8

Target load reductions used for TMDL compliance shown in bold text.

SW-WLA disaggregation method: MDE TMDL Stormwater Toolkit (http://www.mde.state.md.us/programs/Water/TMDL/DataCenter/Pages/TMDLStormwaterToolkit.aspx)

1) Baseline model used to create the TMDL. Chesapeake Bay Program Watershed Model Phase (CBP WM P). To calculate bacteria baseline loads, a flow duration curve approach was employed, using flow strata estimated from USGS daily flow monitoring data and bacteria monitoring data.

2) Published WLA and Reduction % from the MDE TMDL Data Center SW WLAs for County Storm Sewer Systems in Frederick County

3) MDP 2010 LULC urban land area within Frederick County NPDES MS4 Phase I/II source sector in watershed.

4) MDP 2010 LULC urban land area within total NPDES source sectors in watershed.

5) The percent of County MS4 land area was calculated by dividing the total County MS4 urban land area with the total urban NPDES source sector land area of the 8-digit watershed area (MDP, 2010).

6) Disaggregated WLAs were calculated by multiplying MDE published aggregate WLAs by the percentage of County MS4 land within the urban NPDES land area of the 8-digit watershed.

7) Disaggregated reductions were calculated from the disaggregate WLA and reduction % using the following equation: (Disaggregated WLA / (1 - Reduction %)) - Disaggregated WLA

8) Disaggregated baseline loads were calculated by adding the disaggregate WLA and reduction loads.

9) The Lake Linganore watershed is listed under a separate phosphorus and sediment TMDL and is not included in this analysis.

10) Lake Linganore BMPs are not included in Lower Monocacy. These BMPs will be included if a Lake Linganore Frederick County SW-WLA is required

Table 18 - Calibrated Nutrient and Sediment Local TMDL SW-WLAs and Target Load Reductions

Watershed Name	Watershed Number	Baseline Year	Pollutant	MDE Published Reduction %[1]	Baseline Acres (MAST Local TMDL Base Year)[2]		Calibrated Baseline Load EOS-lbs/yr[3]	Calibrated Reduction EOS-lbs/yr[4]	Calibrated WLA EOS-lbs/yr[5]
					County Phase I MS4 Impervious	County Phase I MS4 Pervious			
Catoctin Creek	02140305	2009	Phosphorus	11.0%	1,301.00	6,352.70	7,787.20	**856.59**	6,930.61
		2000	Sediment	49.1%	1,214.90	5,715.50	4,653,075.00	**2,284,659.83**	2,368,415.20
Double Pipe Creek	02140304	2009	Phosphorus	73.0%	240.90	1,186.40	1,350.70	**986.01**	364.68
		2000	Sediment	46.8%	152.50	833.50	505,282.30	**236,472.12**	268,810.18
Lower Monocacy River[6]	02140302	2009	Phosphorus	28.0%	5,715.70	26,120.00	28,358.30	**7,940.32**	20,417.98
		2000	Sediment	60.8%	4,516.90	20,214.00	9,843,363.00	**5,984,764.70**	3,858,598.30
Potomac River Montgomery County	02140202	2005	Sediment	36.2%	10.20	45.80	32,041.20	**11,598.91**	20,442.29
Upper Monocacy River	02140303	2009	Phosphorus	4.0%	879.20	6,653.80	6,386.50	**255.46**	6,131.04
		2000	Sediment	49.0%	764.40	5,434.00	2,376,268.00	**1,164,371.32**	1,211,896.70

Target reduction loads used for TMDL compliance shown in bold text.

1) Published Reduction % from the MDE TMDL Data Center SW WLAs for County Storm Sewer Systems in Frederick County

2) County Phase I MS4 urban impervious and pervious acres for the TMDL baseline year. A query was run using the MAST Compare Scenario tool based on local TMDL watershed split by County and Local Base year.

3) Baseline loads modeled in BayFAST using County BMPs installed prior to the TMDL baseline year on top of baseline land use background loads.

4) Calibrated reductions calculated by applying the MDE published percent reduction to the BayFAST calibrated baseline loads.

5) Calibrated WLAs calculated by subtracting the calibrated reduction from the BayFAST calibrated baseline load.

6) The Lake Linganore watershed is listed under a separate phosphorus and sediment TMDL and is not included in this analysis.

LOWER MONOCACY WATERSHED

Frederick County is currently reviewing its first draft of the Lower Monocacy Watershed Assessment, which will update the Identified scenario in future versions of this Plan.

SEDIMENT TMDL

The Baseline year for the Lower Monocacy Sediment TMDL was 2000. The TMDL requires a 60.8% reduction from baseline, which amounts to 5984764.7 pounds, or 2,992.4 tons.

Table 19: Baseline and Reduction for Lower Monocacy Sediment TMDL

Row Labels	Sum of SLoadEOS
regulated impervious developed	5549752.0
regulated pervious developed	4293611.0
Grand Total	**9843363**
Reduction %	60.8%
Calibrated Reduction	5984764.7
Calibrated WLA	3858598.3

Lower Monocacy sediment scenarios are in Appendix 5.

Table 20: Reductions by Scenario for Lower Monocacy Sediment TMDL

Scenario	Scenario Reduction lbs/yr	Cum Redn lbs/yr	Load lbs/yr	% Redn
Baseline	0	0.00	9,843,363.00	0.0%
Completed	203,328.00	203,328.00	9,640,035.00	3.4%
Programmed	253,033.00	456,361.00	9,387,002.00	7.6%
Identified	2,487,291.00	2,943,652.00	6,899,711.00	49.2%
Potential	3,494,871.70	6,438,523.70	3,404,839.30	107.6%
Calculated Disaggregated County MS4 Redn	5,984,764.70			

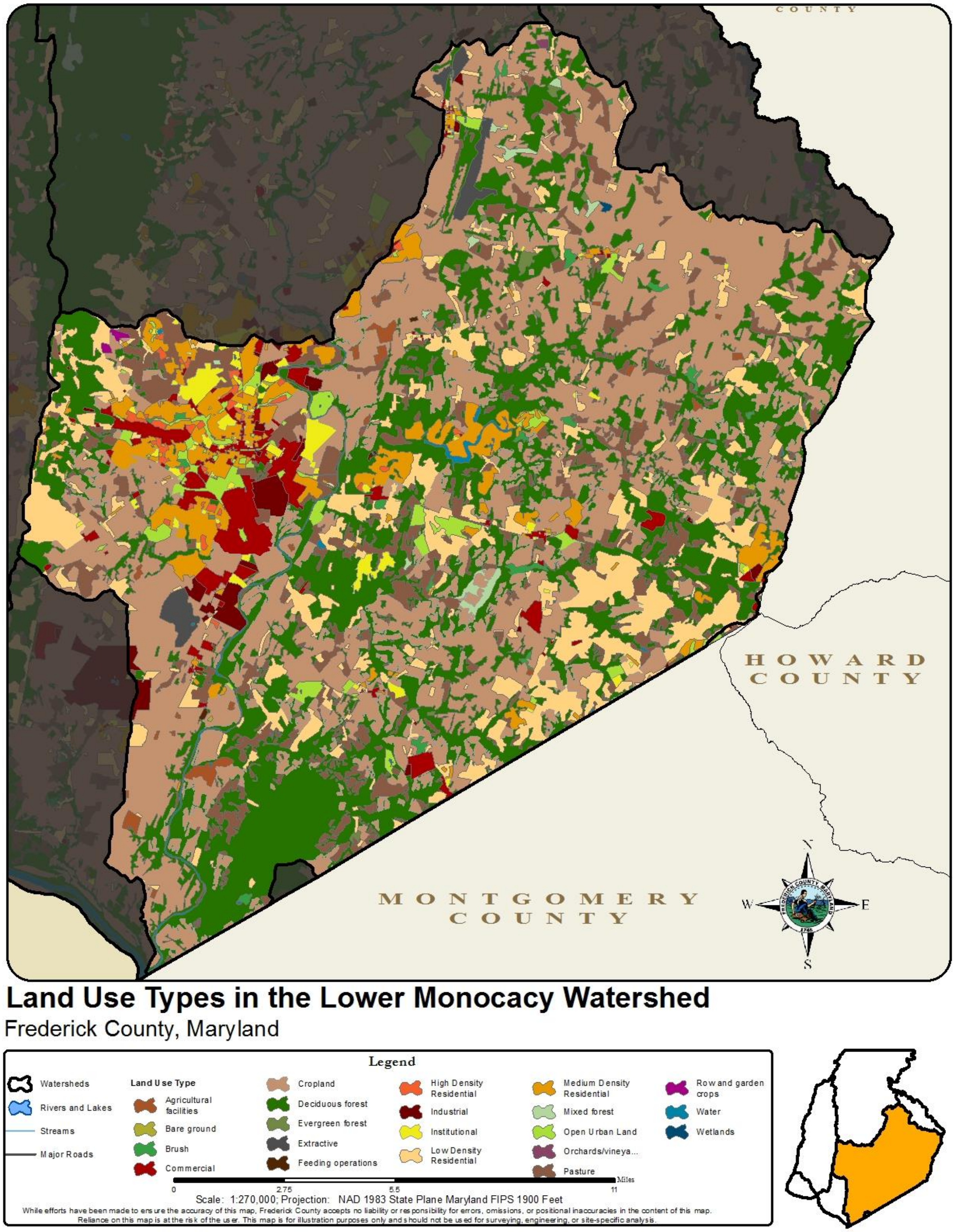


Figure 18: Land Use Types in the Lower Monocacy River Watershed

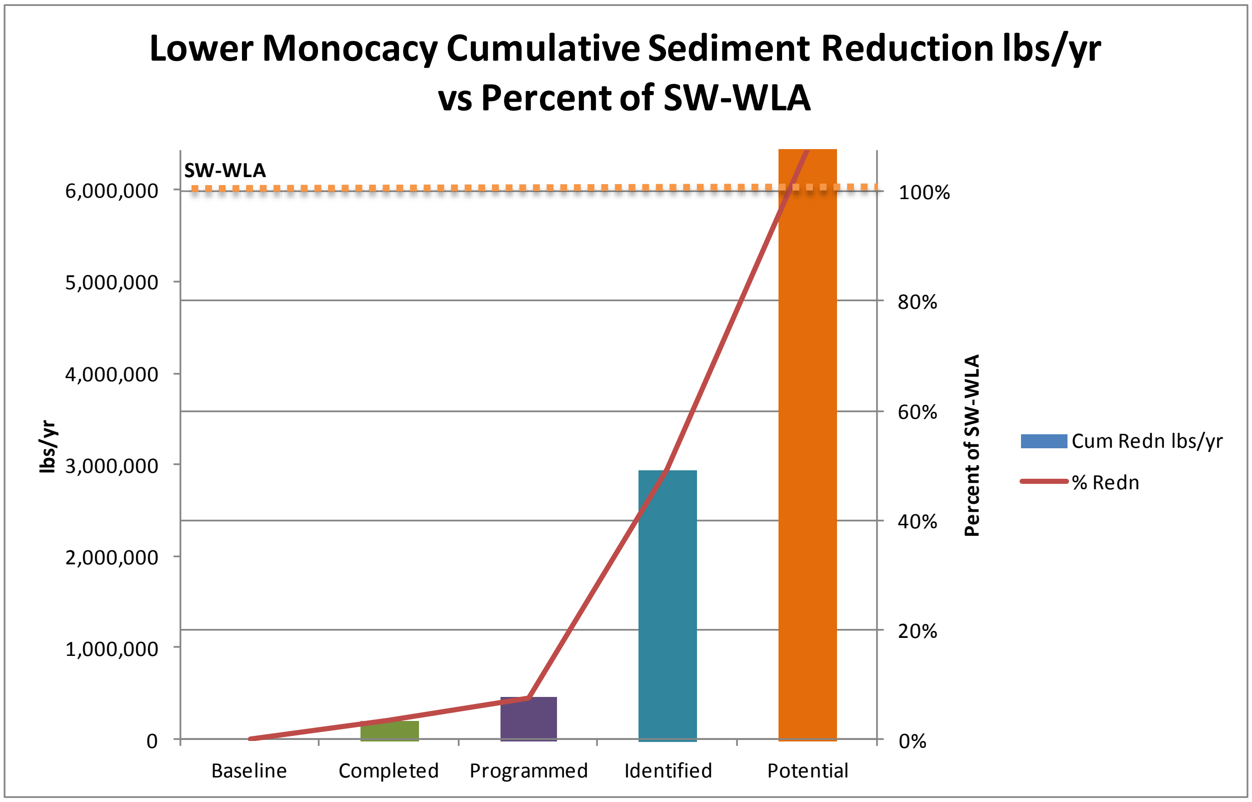


Figure 19: Lower Monocacy Cumulative Sediment Reductions lbs/yr vs. Percent of SW-WLA

PHOSPHORUS TMDL

The Baseline year for the Lower Monocacy phosphorus TMDL was 2009. The TMDL requires a 28.0% reduction from baseline, which amounts to 7,940.3 pounds.

Table 21: Baseline and Reduction for Lower Monocacy Phosphorus TMDL

Row Labels	Sum of PLoadEOS
regulated impervious developed	14557.8
regulated pervious developed	13800.5
Grand Total	**28358.3**
Reduction %	28.0%
Reduction	7940.3
Calibrated WLA	20418.0

Lower Monocacy phosphorus scenarios are in Appendix 6.

Table 22: Reductions by Scenario for Lower Monocacy Phosphorus TMDL

Scenario	Scenario Reduction lbs/yr	Cum Redn lbs/yr	Load lbs/yr	% Redn
Baseline	0	0.00	28,358.30	0.0%
Completed	189.00	189.00	28,169.30	2.4%
Programmed	341.00	530.00	27,828.30	6.7%
Identified	4,008.30	4,538.30	23,820.00	57.2%
Potential	4,537.10	9,075.40	19,282.90	114.3%
Calculated Disaggregated County MS4 Redn	7,940.30			

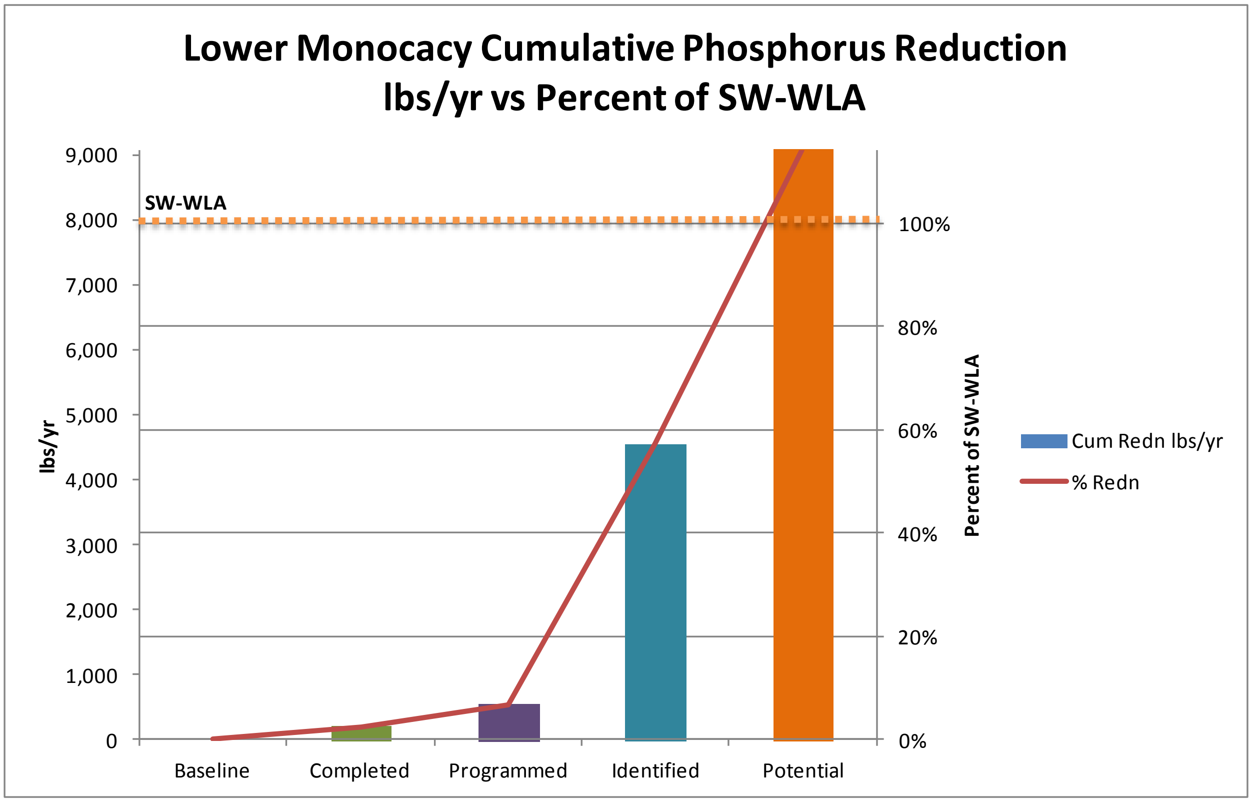


Figure 20: Lower Monocacy Cumulative Phosphorus Reductions lbs/yr vs. Percent of SW-WLA

UPPER MONOCACY WATERSHED

Frederick County has hired EA Engineering to update its Watershed Restoration Assessment for the Upper Monocacy; this Assessment is underway and will be used to update the Identified Scenario in future versions of this Plan. The County has received a Stormwater Master Plan from EA; this plan is undergoing review. Future versions of this Plan will include updates to the Identified Scenario from the Stormwater Master Plan. Previous

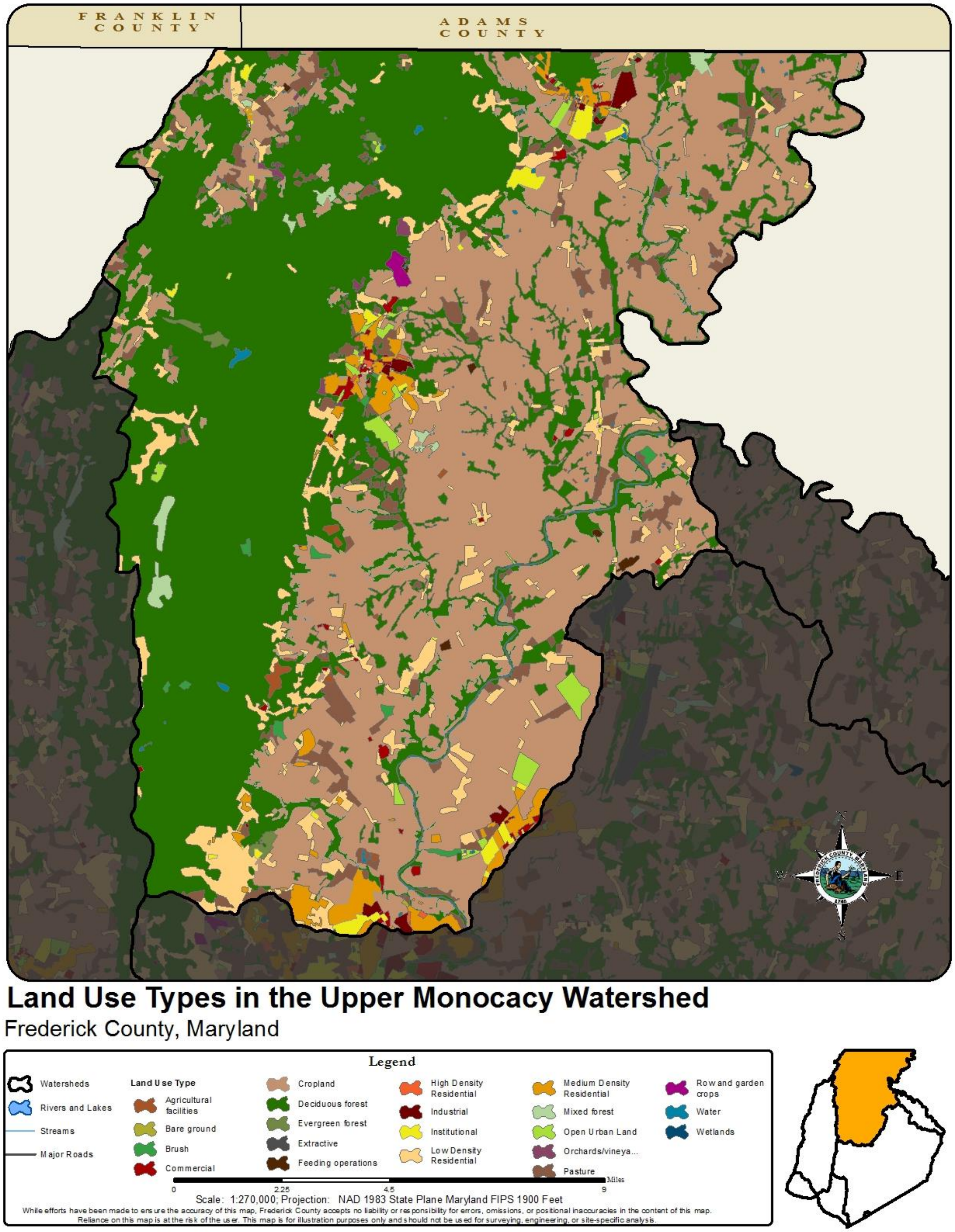


Figure 21: Land Use Types in the Upper Monocacy River Watershed

plans used to develop the Identified Scenario include the Watershed Restoration Action Strategy for the Upper Monocacy Watershed.

SEDIMENT TMDL

The Baseline year for the Upper Monocacy Sediment TMDL was 2000. The TMDL requires a 49.0% reduction from baseline, which amounts to 1,164,371.3 pounds, or 582.2 tons.

Table 23: Baseline and Reduction for Upper Monocacy Sediment TMDL

Baseline	Load
regulated impervious developed	1100958
regulated pervious developed	1275310
Grand Total	**2376268**
Reduction %	49.0%
Calibrated Reduction	1164371.3
Calibrated WLA	1211896.7

Upper Monocacy sediment scenarios are in Appendix 7.

Table 24: Reductions by Scenario for Upper Monocacy Sediment TMDL

Scenario	Scenario Reduction lbs/yr	Cum Redn lbs/yr	Load lbs/yr	% Redn
Baseline	0	0.00	2,376,268.00	0.0%
Completed	1,106.00	1,106.00	2,375,162.00	0.1%
Programmed	35,958.00	37,064.00	2,339,204.00	3.2%
Identified	38,616.00	75,680.00	2,300,588.00	6.5%
Potential	1,100,851.90	1,176,531.90	1,199,736.10	101.0%
Calculated Disaggregated County MS4 Redn	1,164,371.30			

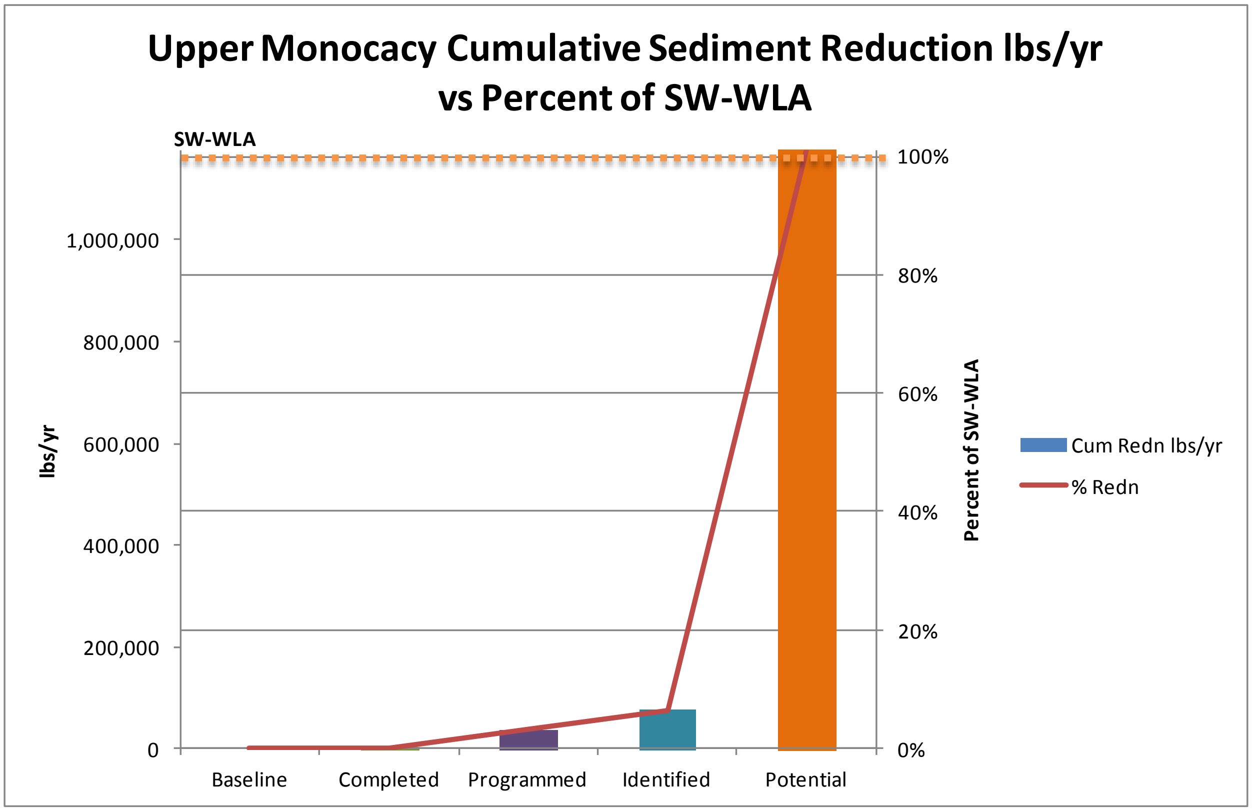


Figure 22: Upper Monocacy Cumulative Sediment Reductions lbs/yr vs. Percent of SW-WLA

PHOSPHORUS TMDL

The Baseline year for the Upper Monocacy phosphorus TMDL was 2009. The TMDL requires a 4.0% reduction from baseline, which amounts to 255.5 pounds.

Table 25: Baseline and Reduction for Upper Monocacy Phosphorus TMDL

Row Labels	Sum of PLoadEOS
regulated impervious developed	2520.8
regulated pervious developed	3865.7
Grand Total	**6386.5**
reduction %	4.0%
Reduction	255.5
Calibrated WLA	6131.0

Upper Monocacy phosphorus scenarios are in Appendix 8.

Table 26: Reductions by Scenario for Upper Monocacy Phosphorus TMDL

Scenario	Scenario Reduction lbs/yr	Cum Redn lbs/yr	Load lbs/yr	% Redn
Baseline	0	0.00	6,386.50	0.0%
Completed	2.70	2.70	6,383.80	1.1%
Programmed	87.10	89.80	6,296.70	35.1%
Identified	71.20	161.00	6,225.50	63.0%
Potential	241.20	402.20	5,984.30	157.4%
Calculated Disaggregated County MS4 Redn	255.50			

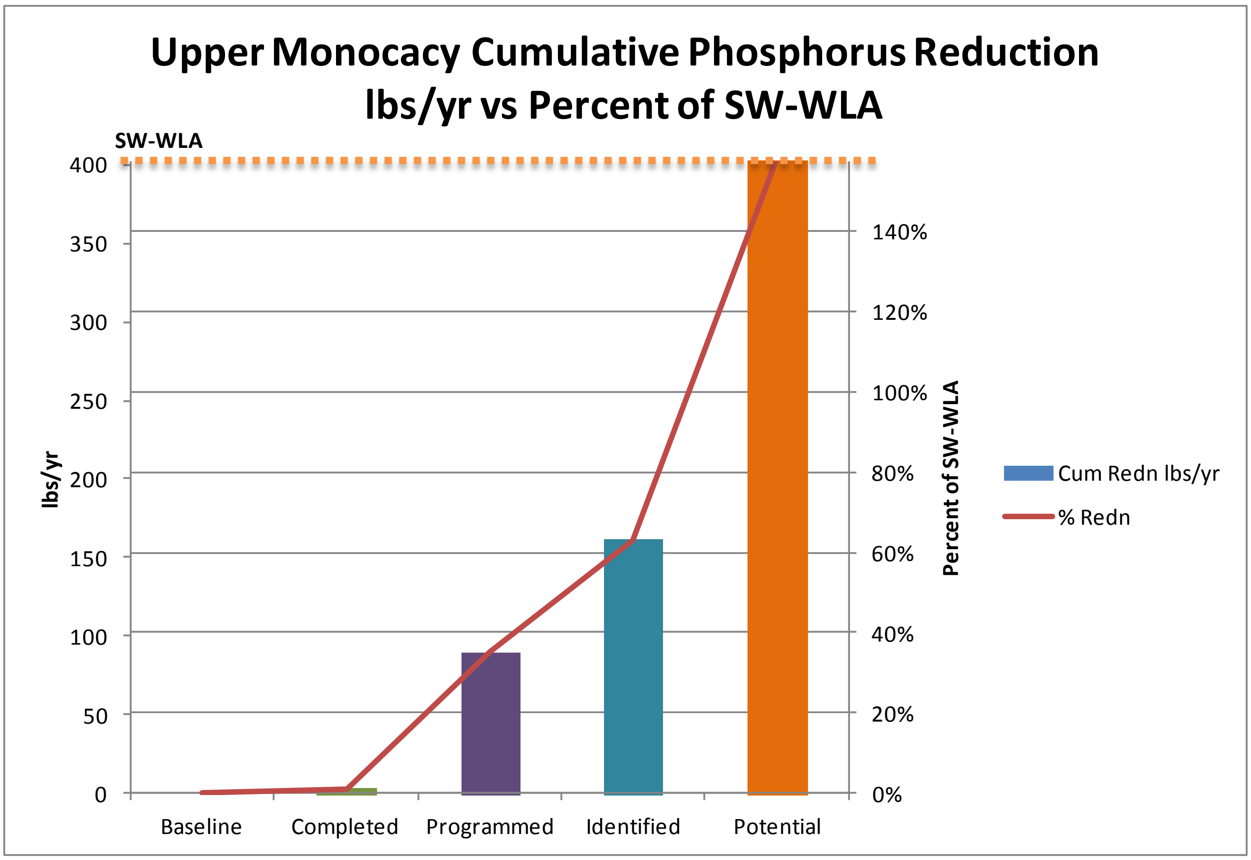


Figure 23: Upper Monocacy Cumulative Phosphorus Reductions lbs/yr vs. Percent of SW-WLA

CATOCTIN CREEK WATERSHED

SEDIMENT TMDL

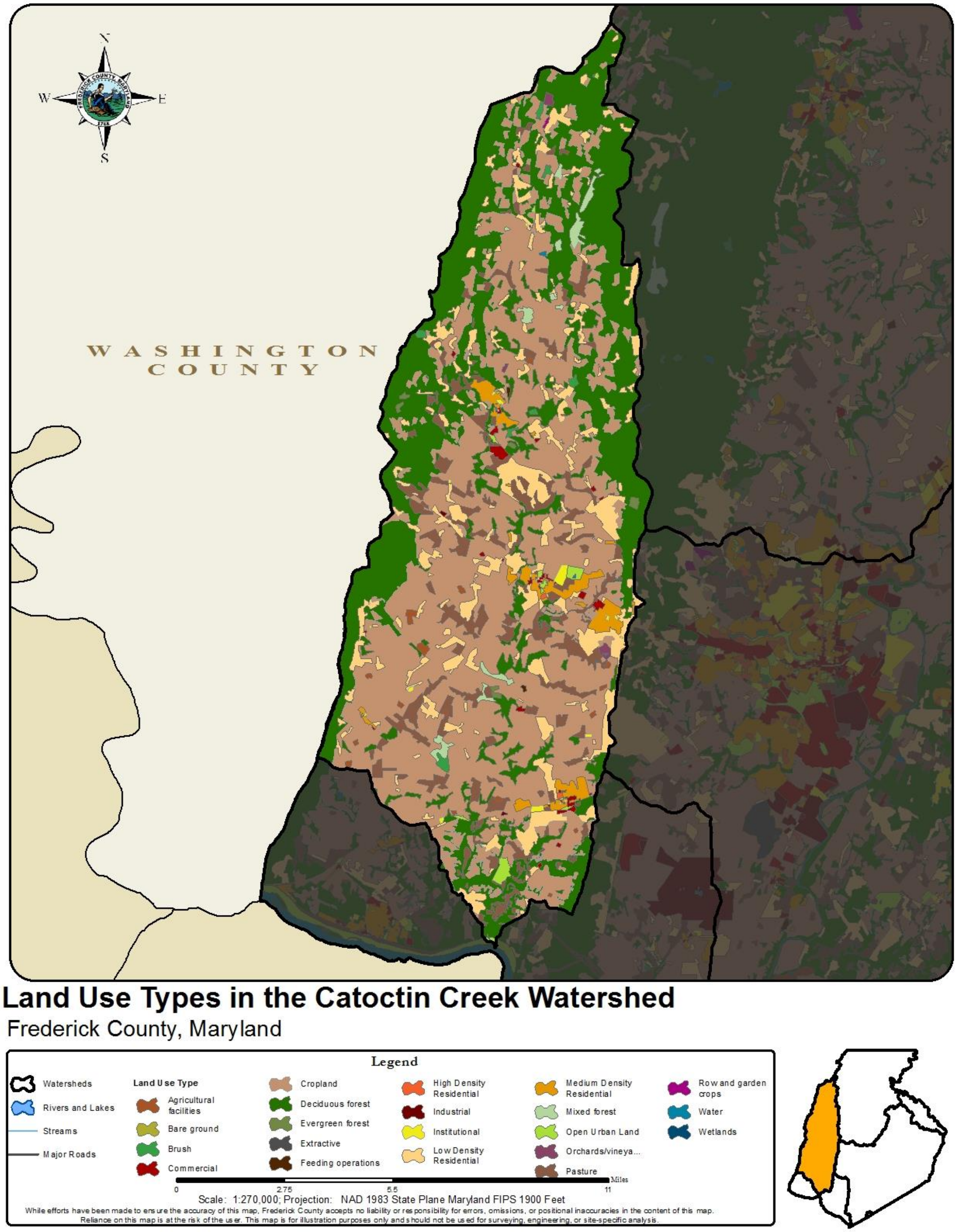


Figure 24: Land Use Types in Catoctin Creek

The Baseline year for the Catoctin Creek Sediment TMDL was 2000. The TMDL requires a 49.1% reduction from baseline, which amounts to 2284659.8 pounds, or 1142.3 tons.

Table 27: Baseline and Reduction for Catoctin Creek Sediment TMDL

Row Labels	Sum of SLoadEOS
regulated impervious developed	2671329
regulated pervious developed	1981746
Grand Total	**4653075**
Reduction %	49.1%
Calibrated reduction	2284659.8
Calibrated WLA	2368415.2

Catoctin Creek sediment scenarios are in Appendix 9.

Table 28: Reductions by Scenario for Catoctin Creek Sediment TMDL

Scenario	Scenario Reduction lbs/yr	Cum Redn lbs/yr	Load lbs/yr	% Redn
Baseline	0	0.00	4,653,075.00	0.0%
Completed	6,291.00	6,291.00	4,646,784.00	0.3%
Programmed	58,438.00	64,729.00	4,588,346.00	2.8%
Identified	108,431.00	173,160.00	4,479,915.00	7.6%
Potential	2,169,069.30	2,342,229.30	2,310,845.70	102.5%
Calculated Disaggregated County MS4 Redn	2,284,659.80			

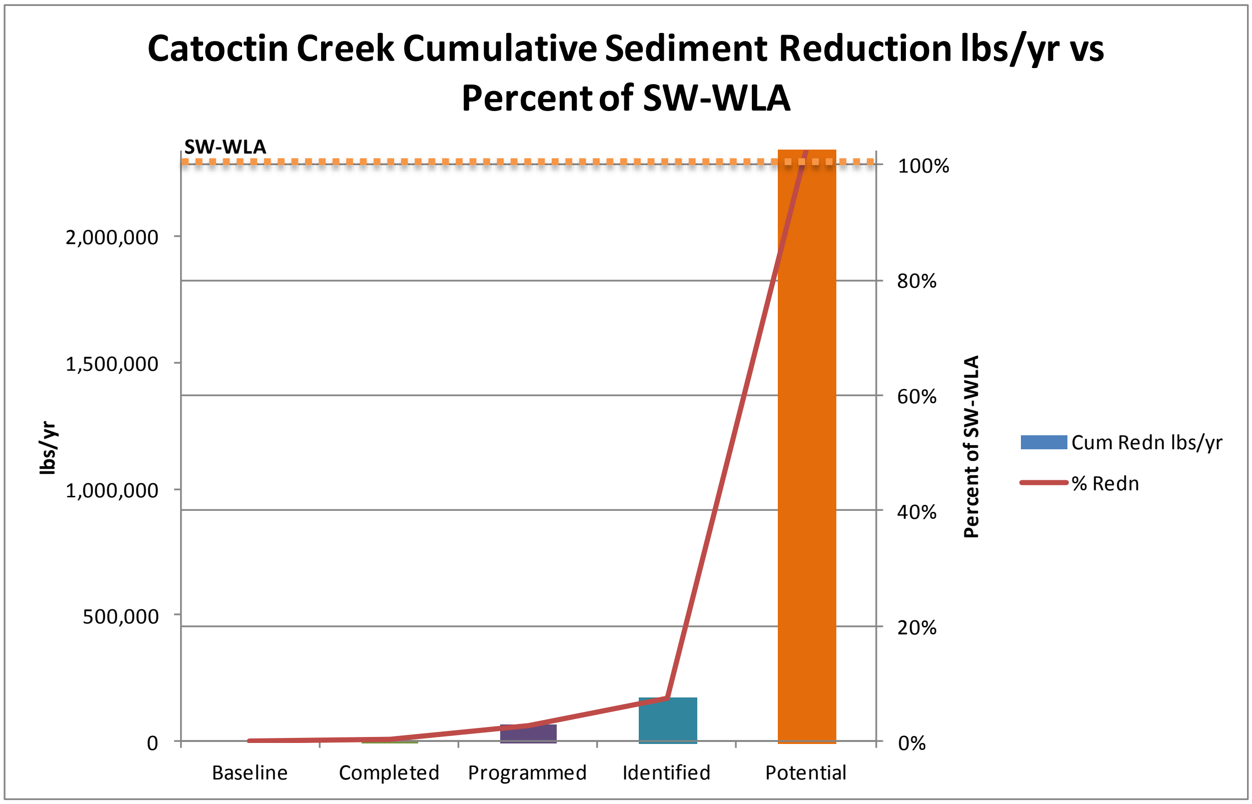


Figure 25: Catoctin Creek Cumulative Sediment Reductions lbs/yr vs. Percent of SW-WLA

PHOSPHORUS TMDL

The Baseline year for the Catoctin Creek phosphorus TMDL was 2009. The TMDL requires an 11.0% reduction from baseline, which amounts to 856.6 pounds.

Table 29: Baseline and Reduction for Catoctin Creek Phosphorus TMDL

Row Labels	Sum of PLoadEOS
regulated impervious developed	3901.3
regulated pervious developed	3885.9
Grand Total	**7787.2**
Reduction %	11.0%
Reduction	856.6
Calibrated WLA	6930.6

Catoctin Creek phosphorus scenarios are in Appendix 10.

Table 30: Reductions by Scenario for Catoctin Creek Phosphorus TMDL

Scenario	Scenario Reduction lbs/yr	Cum Redn lbs/yr	Load lbs/yr	% Redn
Baseline	0	0.00	7,787.20	0.0%
Completed	10.60	10.60	7,776.60	1.2%
Programmed	91.20	101.80	7,685.40	11.9%
Identified	135.80	237.60	7,549.60	27.7%
Potential	798.80	1,036.40	6,750.80	121.0%
Calculated Disaggregated County MS4 Redn	856.60			

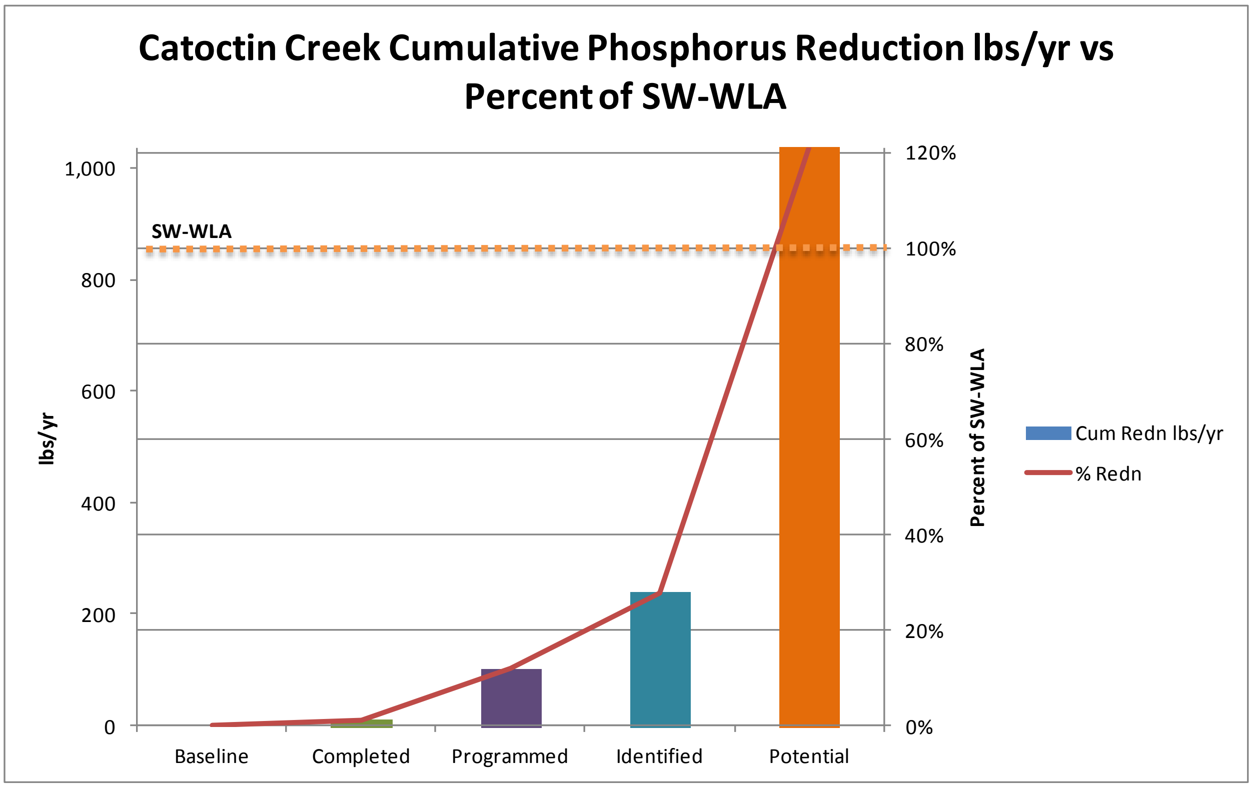


Figure 26: Catoctin Creek Cumulative Phosphorus Reductions lbs/yr vs. Percent of SW-WLA

DOUBLE PIPE CREEK WATERSHED

SEDIMENT TMDL:

The Baseline year for the Double Pipe Creek Sediment TMDL was 2000. The TMDL requires a 46.8% reduction from baseline, which amounts to 236472.1 pounds, or 118.2 tons.

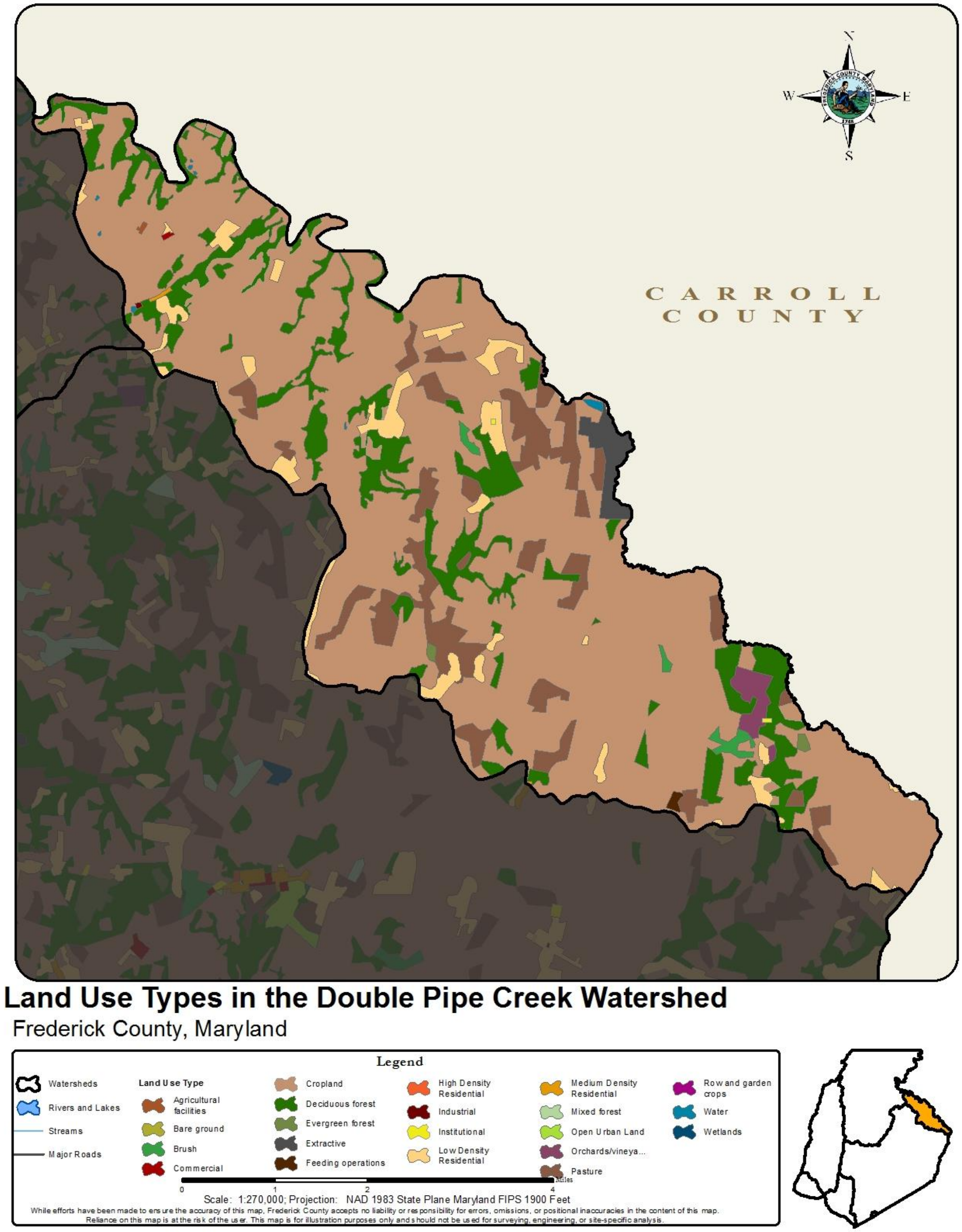


Figure 27: Land Use Types in Double Pipe Creek

Table 31: Baseline and Reduction for Double Pipe Creek Sediment TMDL

Row Labels	Sum of SLoadEOS
regulated impervious developed	269944.9
regulated pervious developed	235337.4
Grand Total	**505282.3**
Reduction %	46.8%
Calibrated Reduction	236472.1
Calibrated WLA	268810.2

Double Pipe Creek sediment scenarios are in Appendix 11.

Table 32: Reductions by Scenario for Double Pipe Creek Sediment TMDL

Scenario	Scenario Reduction lbs/yr	Cum Redn lbs/yr	Load lbs/yr	% Redn
Baseline	0	0.00	505,282.30	0.0%
Completed	0.00	0.00	505,282.30	0.0%
Programmed	5,925.80	5,925.80	499,356.50	2.5%
Identified	7,755.60	13,681.40	491,600.90	5.8%
Potential	241,514.10	255,195.50	250,086.80	107.9%
Calculated Disaggregated County MS4 Redn	236,472.10			

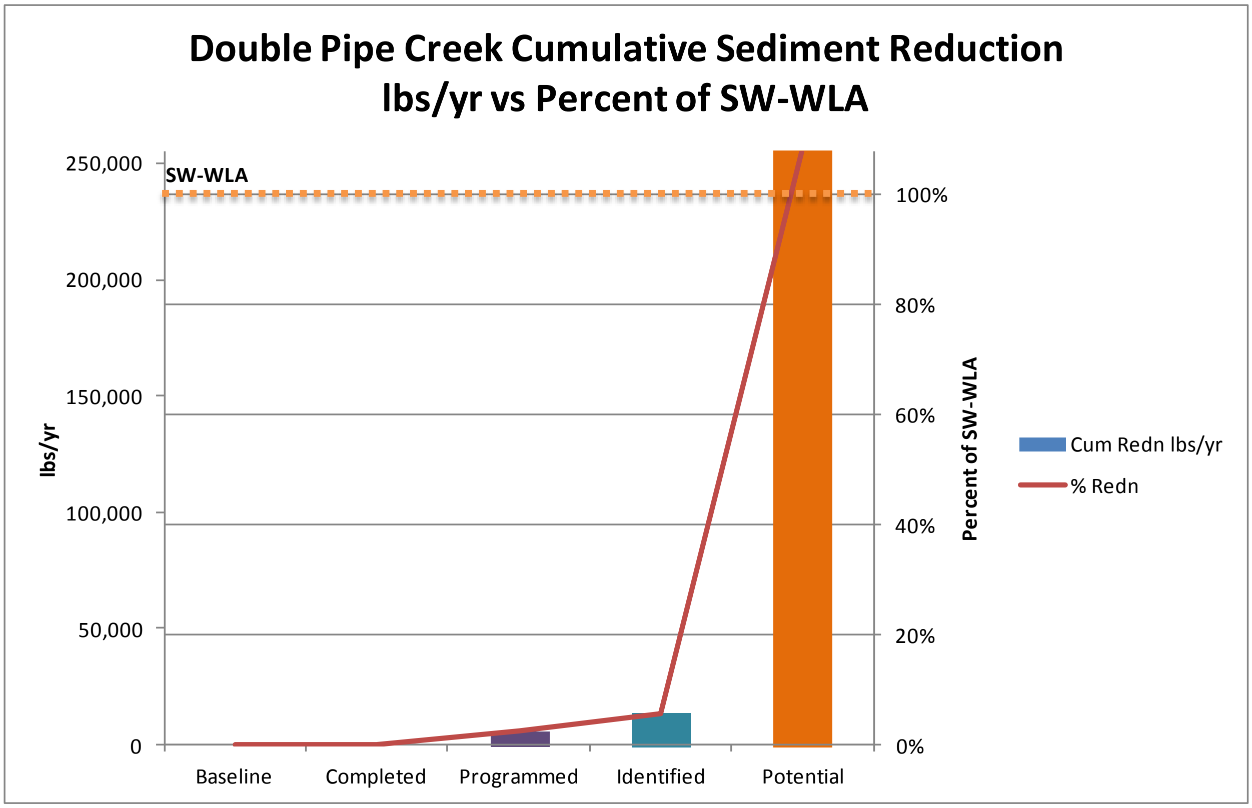


Figure 28: Double Pipe Creek Cumulative Sediment Reductions lbs/yr vs. Percent of SW-WLA

PHOSPHORUS TMDL:

The Baseline year for the Double Pipe Creek phosphorus TMDL was 2009. The TMDL requires a 73.0% reduction from baseline, which amounts to 986.0 pounds.

Table 33: Baseline and Reduction for Double Pipe Creek Phosphorus TMDL

Row Labels	Sum of PLoadEOS
regulated impervious developed	686.1
regulated pervious developed	664.6
Grand Total	**1350.7**
Reduction %	73.0%
Reduction	986.0
Calibrated WLA	364.7

Double Pipe Creek Phosphorus scenarios are in Appendix 12.

Table 34: Reductions by Scenario for Double Pipe Creek Phosphorus TMDL

Scenario	Scenario Reduction lbs/yr	Cum Redn lbs/yr	Load lbs/yr	% Redn
Baseline	0	0.00	1,350.70	0.0%
Completed	0.00	0.00	1,350.70	0.0%
Programmed	11.50	11.50	1,339.20	1.2%
Identified	12.30	23.80	1,326.90	2.4%
Potential	910.70	934.50	416.20	94.8%
Calculated Disaggregated County MS4 Redn	986.00			

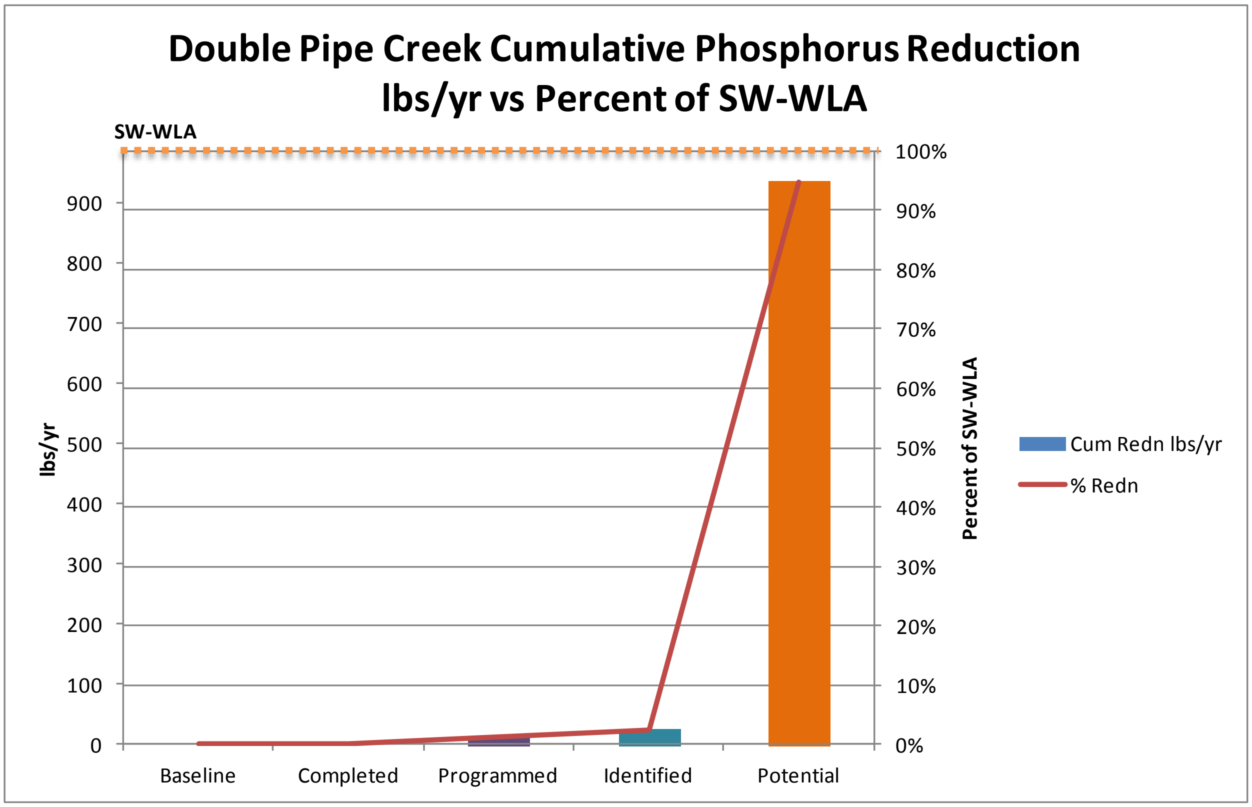


Figure 29: Double Pipe Creek Cumulative Phosphorus Reductions lbs/yr vs. Percent of SW-WLA

POTOMAC DIRECT (FREDERICK COUNTY) WATERSHED

Frederick County's consultants completed an assessment for watershed restoration opportunities in the point of rocks neighborhood. The County is currently reviewing this assessment and will include projects in the Identified scenario in the next version of this Plan.

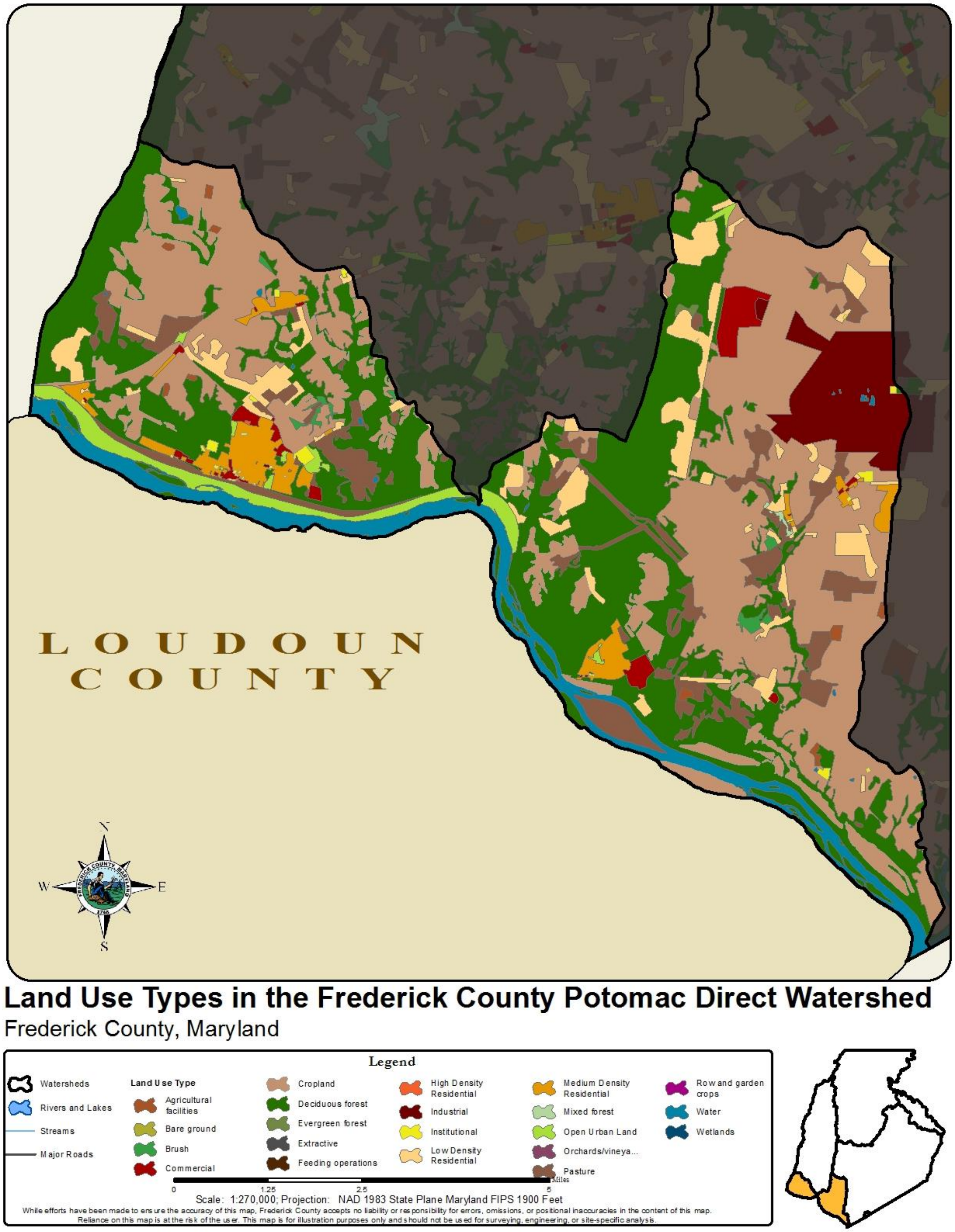


Figure 30: Land Use Types in Potomac Direct

SEDIMENT TMDL:

The Baseline year for the Potomac Direct Sediment TMDL was 2000. The TMDL requires a 36.2% reduction from baseline, which amounts to 11598.9 pounds, or 5.8 tons.

Table 35: Baseline and Reduction for Potomac Direct Sediment TMDL

Row Labels	Sum of SLoadEOS
regulated impervious developed	18564.6
regulated pervious developed	13476.6
Grand Total	**32041.2**
Reduction %	36.2%
Calibrated Reduction	11598.9
Calibrated WLA	20442.3

Potomac Direct sediment scenarios are in Appendix 13.

Table 36: Reductions by Scenario for Potomac Direct Sediment TMDL

Scenario	Scenario Reduction lbs/yr	Cum Redn lbs/yr	Load lbs/yr	% Redn
Baseline	0	0.00	32,041.20	0.0%
Completed	284.90	284.90	31,756.30	2.5%
Programmed	26,013.00	26,297.90	5,743.30	226.7%
Calculated Disaggregated County MS4 Redn	11,598.90			

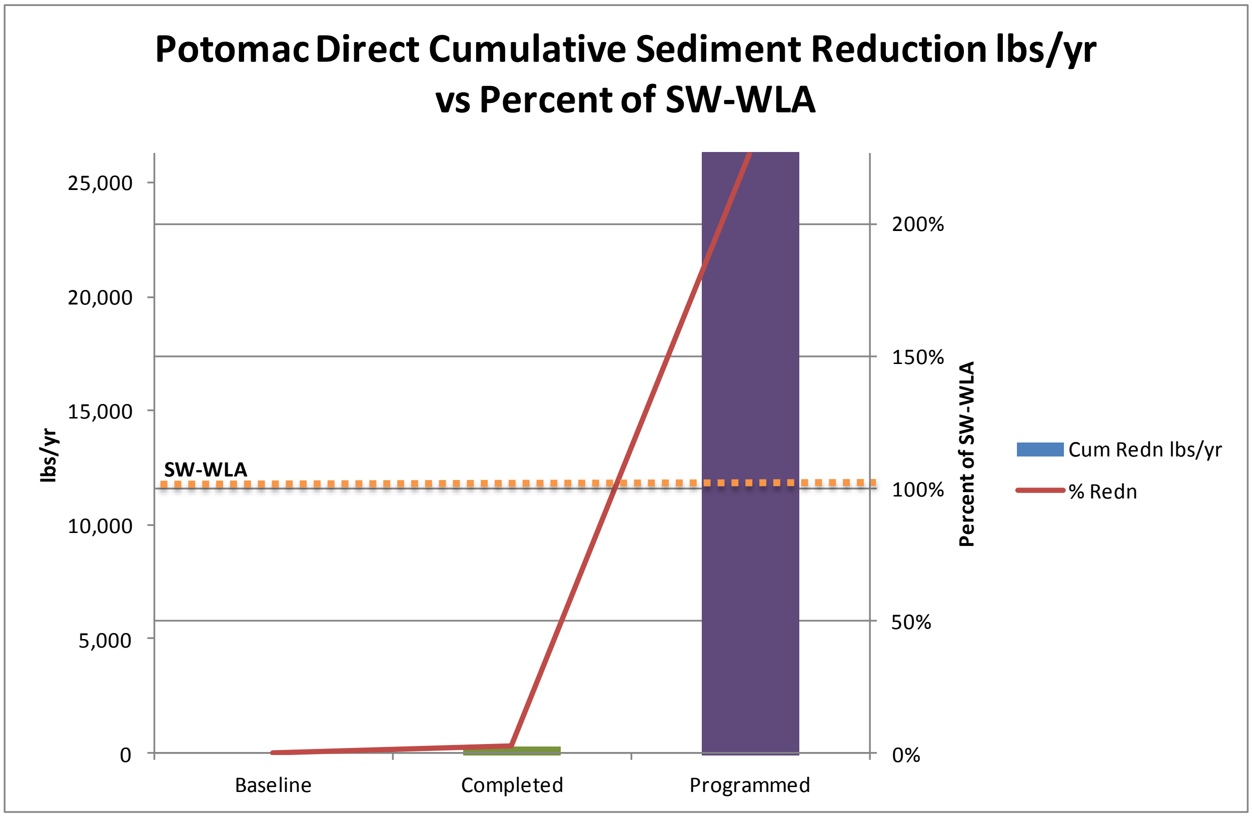


Figure 31: Potomac Direct Cumulative Sediment Reductions lbs/yr vs. Percent of SW-WLA

CONCLUSION

The nine local sediment and phosphorus TMDLs addressed in this document are in the table below. Each TMDL's SW-WLA for Frederick County Government's MS4 is met by this Plan.

Table 37 - Frederick County Local TMDLs with SW-WLAs and Reductions met by TMDL Restoration Plans

Segment	Impairment	SW-WLA	Reduction	Units
Catoctin Creek	Phosphorus	6,930.61	856.59	Lbs/yr
Catoctin Creek	Sediment	2,368,415.20	2,284,659.83	Lbs/yr
Double Pipe Creek	Phosphorus	364.68	986.01	Lbs/yr
Double Pipe Creek	Sediment	268,810.18	236,472.12	Lbs/yr
Lower Monocacy River	Phosphorus	20,417.98	7,940.32	Lbs/yr
Lower Monocacy River	Sediment	3,858,598.30	5,984,764.70	Lbs/yr
Potomac River Mo. County	Sediment	20,442.29	11,598.91	Lbs/yr
Upper Monocacy River	Phosphorus	867,710.8	255.46	Lbs/yr
Upper Monocacy River	Sediment	6,131.04	1,164,371.32	Lbs/yr

The Chesapeake Bay TMDL for nitrogen includes all best management practices required to meet all other Frederick County TMDLs with the exception of some programmatic BMPs for *E. coli*. For this reason the Chesapeake Bay TMDL Restoration Plan for Nitrogen governs the schedules and costs for all other TMDLs. The following reductions are achieved by subwatershed under the Chesapeake Bay TMDL Restoration Plan for Nitrogen:

Table 38: Edge of Stream and Delivered loads in Chesapeake Bay Nitrogen TMDL Restoration Plan

Segment	Acres	N Load EOS	N Load DEL	P Load EOS	P Load DEL	S Load EOS	S Load DEL
Catoctin Creek	7653.64	167072	54504.11	4975.96	2334.39	3173334.28	2055982.09
Double Pipe Creek	1427.22	29717.89	7387.7	1008.94	473.33	573474.29	371550.14
Lower Monocacy River	31835.76	555804.52	313074.87	10562.94	4955.43	2632748.7	1705740.28
Potomac River FR Cnty	3656.79	76127.69	56101.74	3022.12	1417.77	1329669.91	861484.23
Potomac River MO Cnty	53	1144.09	886.3	51.1	23.97	19422.4	12583.64
Upper Monocacy River	7532.97	153151.39	64046.82	3849.06	1805.72	1534041.09	993894.94
Grand Total	52159.38	983017.58	496001.54	23470.12	11010.61	9262690.67	6001235.32

ESCHERICHIA COLI TMDL RESTORATION PLANS

Septic Tank Replacement with Denitrification

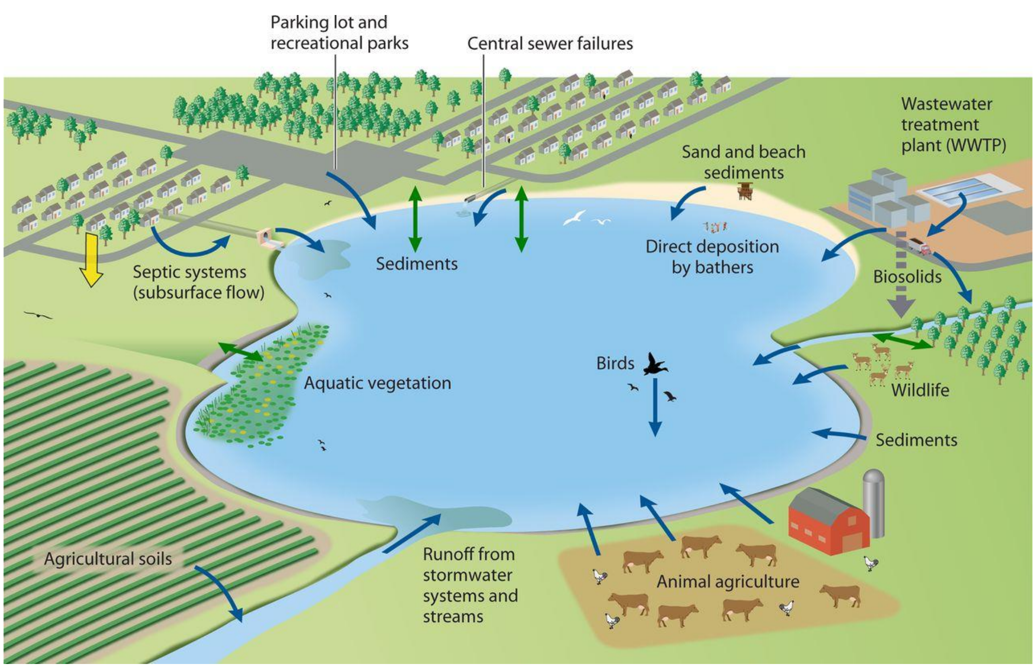
E. COLI AS A SOURCE OF IMPAIRMENT

E. coli is a single celled bacteria that falls into a class of fecal coliform bacteria, which is a subclass of total coliform bacteria. Originating in the excrement of warm-blooded animals, some strains of *E. coli* pose a risk for "body-contact recreation, for consumption of molluscan bivalves (shellfish), and for drinking water. Excessive amounts of fecal bacteria in surface water used for recreation are known to indicate an increased risk of pathogen-induced illness to humans. Infections due to pathogen-contaminated recreation waters include gastrointestinal respiratory, eye, ear, nose, throat, and skin diseases (US EPA 1986)." Per MDE, The key priority for plans to reduce *E. coli* is to "address human sources due to the greater health risk". (MDE Bacteria 2014)

For the TMDL analysis, "Bacteria source tracking (BST) was used to identify the relative contributions from various sources of bacteria to in-stream water samples…Sources are defined as domestic (pets and human associated animals), human (human waste), livestock (agricultural animals), and wildlife (mammals and waterfowl). To identify sources, samples are collected within the watershed from known fecal sources, and the patterns of antibiotic resistance of these known sources are compared to isolates of unknown bacteria from ambient water samples." (MDE DP 2009)

SOURCES OF IMPAIRMENT AND CONTROL

The graphic below is from Byappanahalli (2012). According to the graphic, "sources of enterococci in water bodies (blue arrows) as well as sinks where enterococci are immobilized (yellow arrow) and areas of flux, in which enterococci can transition from a reservoir to the water column and vice versa (green arrows). Fluxes act as secondary sources or sinks depending upon the conditions."



Muruleedhara N. Byappanahalli et al. Microbiol. Mol. Biol. Rev. 2012;76:685-706

Microbiology and Molecular Biology Reviews

Figure 32: Sources and Sinks of *E. coli* from Byappanahalli 2012

Primary sources and controls of *E. coli* bacteria from urban stormwater and into storm sewer systems follow:

HUMAN SOURCES

Per MDE (MDE Bacteria 2014) the plan must show measures to be taken "to correct failing or faulty human waste collection infrastructure (e.g., combined sewer overflows, illicit connections and discharges, cross-connections, leaking pipes, or separate sewer overflows) discharging into the MS4 stormwater collection system."

SEPTIC SYSTEMS

Loads for septic systems in the WTM are based on a loading rate for system type with attenuation through a number of physical processes as well as a standard rate of decay. The number of septic systems was calculated based on the inverse of properties in the county served by sewer in a GIS exercise. Systems are assumed to be conventional, and can be improved upon in a number of ways:

- Septic repairs fix a failing septic system. The Health Department has reported 102 of these in the past 5 years. 50 are attributed to the Upper Monocacy, 40 to the Lower Monocacy, and 12 to Double Pipe Creek.
- Septic system education is designed to prevent failures through proper management of systems. Effectiveness is based on awareness and willingness to change. A septic system education program will be created in the current permit cycle in the Programmed scenario to meet these goals. A 40% willingness to change is assumed based on Swann (1999) and an awareness factor of 40% is used for a media campaign that includes television.
- Septic upgrades switch from a less functioning system to a better functioning system. Upgrades to denitrification systems using Bay Restoration Funds are counted in this category. Most of the systems in Frederick County installed through the BRF are Norweco Singulair and TNT. The systems installed use bacteria to fix nitrogen; thus UV or disinfection to remove *E. coli* is not used for these systems. They have a bacteria removal efficiency similar to conventional systems with a log reduction of 3.5. 5 septic systems in Double Pipe Creek have been upgraded in the past 5 years, along with 65 in the Lower Monocacy and 60 in the Upper Monocacy. These data were reported by the Health Department.
- Septic connection retirement to sewer requires the ability to connect a system to a sewer line, so they are not common. The county has completed seven of these in the past ten years. This information was reported by the Planning Department.

SANITARY SEWER OVERFLOW REPAIR AND ABATEMENT

The table below outlines the elements of the SSO abatement program as reported for Chesapeake Bay Two Year Milestones. The goal of the program is a 100% reduction of SSOs. This same program also addresses inflow and infiltration projects, which are not included in the WTM but have an impact on the reduction of losses from the sanitary sewer.

Table 39: SSO Abatement Activities from Frederick County 2014 - 2015 Programmatic Two-Year Implementation Milestones and Interim Progress Reporting

Target Date	Milestone	Deliverable
July 1, 2012 to June 30, 2013	Sanitary Sewer Overflow (SSO) Reduction	• Sewage Pump Station Upgrades ○ College Run SPS Upgrade Study ○ Ceresville SPS Pump Analysis Study

		• Sewer Line Televised Inspection Program
		  ○ All sewer lines 10" and larger
		• Sewer Line Cleaning
		  ○ Main Lines
		  ○ Laterals
		• Inflow and Infiltration Projects
		  ○ Greenview and West New Market
		  ○ Point of Rocks
		  ○ Jefferson
		  ○ Monocacy
		  ○ Ballenger
		  ○ Buckeystown
		  ○ Linganore

July 1, 2013 to June 30, 2014	Sanitary Sewer Overflow (SSO) Reduction	• Sewage Pump Station Upgrades
		  ○ Limestone Lane SPS Replacement
		• Sewer Line Televised Inspection Program
		  ○ Follow up to large diameter inspection program
		• Sewer Line and Manhole Replacements
		  ○ Ballenger
		• Sewer Line Cleaning
		  ○ Main Lines
		  ○ Laterals
		• Inflow and Infiltration Projects
		  ○ Crestview
		  ○ Cloverhill
		  ○ Discovery
		• Root Control Projects
		  ○ White Rock
		  ○ Countryside
		  ○ Farmbrook
		• Smoke Testing
		  ○ Discovery
		  ○ Cloverhill

July 1, 2014 to June 30, 2015	Sanitary Sewer Overflow (SSO) Reduction	• Sewage Pump Station Upgrades
		  ○ College Run SPS Upgrade - Design
		• Sewage Pump Station Pump Replacement
		  ○ Summerfield SPS
		  ○ Cambridge Farms SPS
		  ○ Westwinds SPS
		• Sewer Line Televised Inspection Program
		  ○ Crestview
		  ○ Fountaindale
		  ○ White Rock
		• College Run SPS Upgrade - Design Inflow and Infiltration Projects
		  ○ Crestview
		  ○ Fountaindale
		  ○ White Rock
		  ○ Mill Bottom
		• Sewer Line and Manhole Replacements
		  ○ Ballenger-McKinney

- Crestview
- Fountaindale
- White Rock

- Sewer Line Cleaning
  - Main Lines
  - Laterals
- Root Control Projects
  - Cloverhill
  - Discovery
  - Jefferson

SSO load data were collected and compiled by the Division of Utilities and Solid Waste Management. Loads during MDE's baseline period (September 2013 to November 2014) were used as the baseline SSO load. Loads were converted from gallons to Billion MPN using factors in the WTM. A linear regression was applied to yearly loads thereafter to look at the trajectory of SSO reductions. SSOs can be but are not always dependent on weather events. Loads show a general downward trend with heavy variability. The Division has a goal of zero SSOs, and the reduction goal is 100% for the Upper and Lower Monocacy Watersheds. The Double Pipe Creek Watershed does not have any County-owned SSOs.

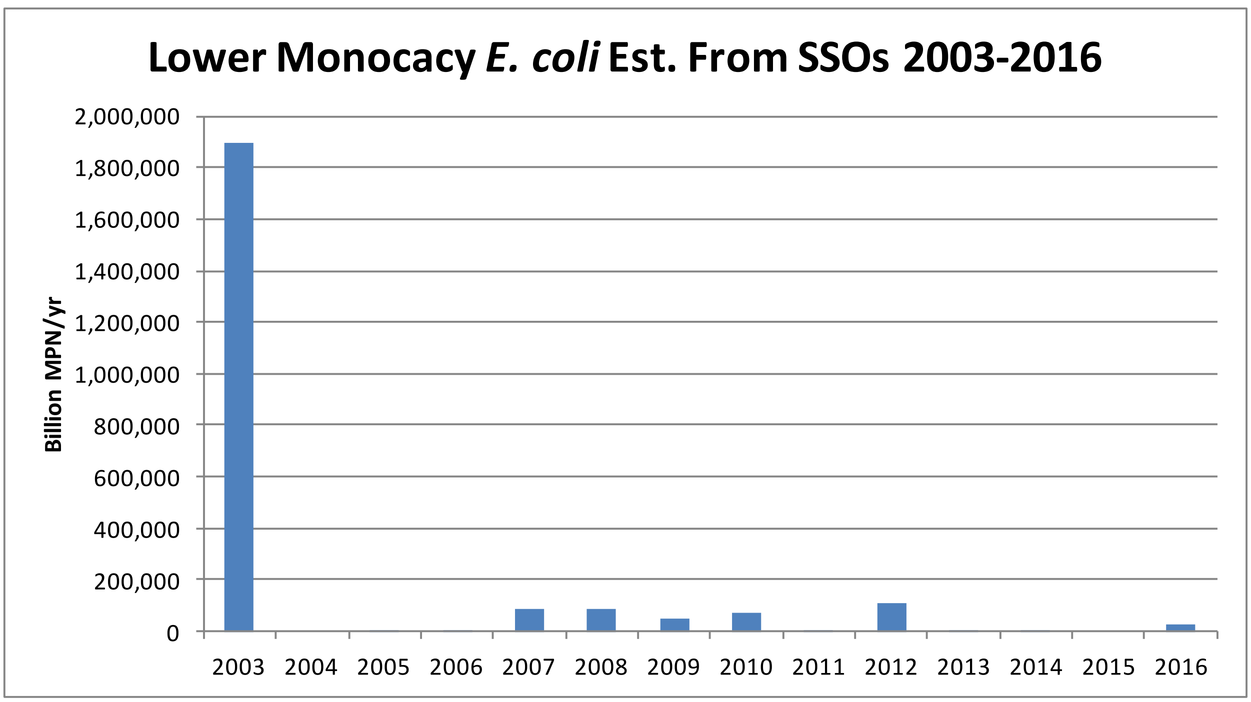


Figure 33: Lower Monocacy SSOs 2003-2016

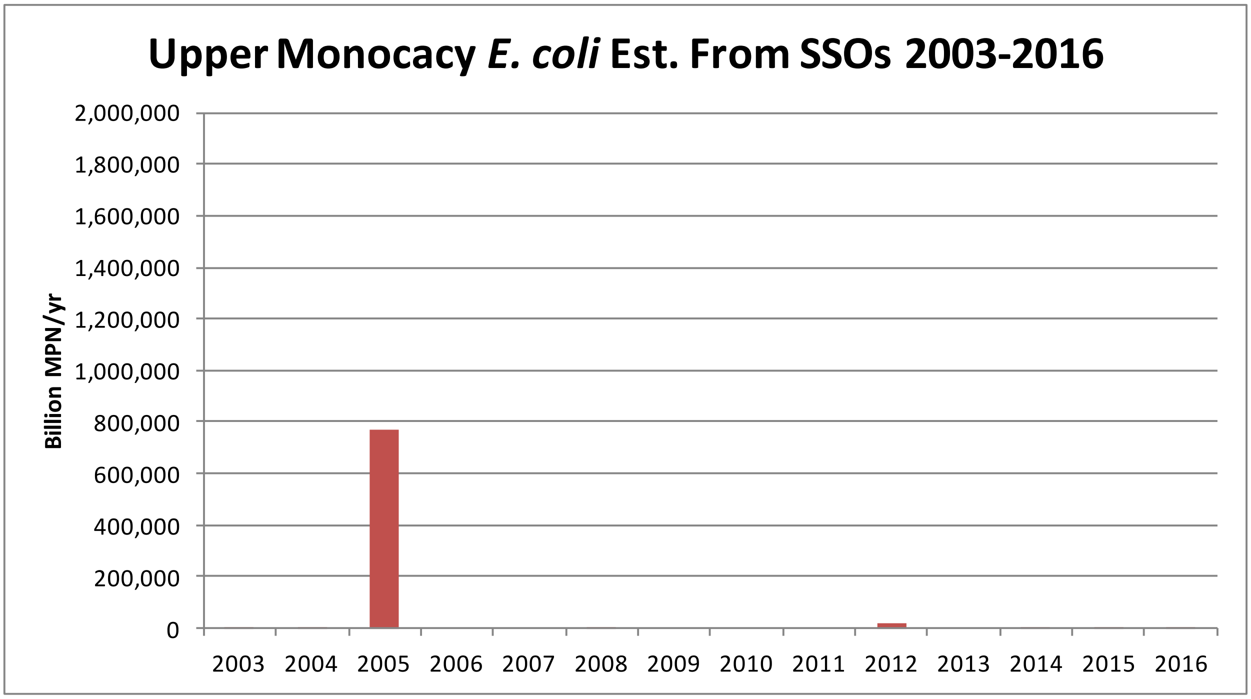


Figure 34: Upper Monocacy SSOs 2003-2016

ELIMINATION OF HOUSEHOLD ILLICIT CONNECTIONS

For residential connections, WTM assumes 1/1000 sewered individuals are connected illicitly. After multiplying that value by the number of connected individuals, this is multiplied by typical per capita flow and concentration rates for raw sewage. For businesses, WTM combines wash water connections and complete wastewater connections. Default values for businesses are 10% assumed illicit connections, and of those, 10% are assumed to have direct sewage discharges.

Frederick County Government has a program to control household illicit connections to the storm sewer system. . The County's IDDE Program identifies potential illicit discharges in three ways: (1) through dry weather screenings completed during as-built inspections and/or triennial maintenance inspections, (2) through citizen and/or agency reporting, and (3) during biological stream sampling within 75 meter segments of the stream. More information about these programs is available in the County's NPDES MS4 Annual Reports. MDE asked Frederick County in its 2015 NPDES MS4 Permit Annual Report Review to revise its IDDE protocol to be more comprehensive.

DOMESTIC PET SOURCE ELIMINATION

PUBLIC LAND

MDE (MDE Bacteria 2014) advocates using agencies such as the park service and public works to improve and/or maintain services such as trash collection and pet waste disposal. The County should work with these entities and review trash collection to identify any potential improvements. These entities should also be part of the discussion of how to properly implement the pet waste management program. Specifically, the program should include:

- Installation of pet waste stations in areas identified as high dog-walking spots, such as parks and sidewalks

- Assuring the proper management of pet waste stations (such as the regular emptying of waste and replenishment of biodegradable bags)
- A protocol for trash collection and waste disposal, ideally with an identified leader/coordinator who has input from all parties
- Increasing the amount of signage of leash laws and the presence of rangers in parks to support leash law abidance. Possible signs include (VA DEQ, 2011):
    - Picking up your pet's waste helps keep our water clean
    - Pet waste contains bacteria that damages waterways
    - Removal of pet waste required by an ordinance.
    - Neighbors enjoy NOT having to avoid doggie poop while out walking
    - Location of pet waste stations
    - Period reminders

PRIVATE LAND

MDE states that "education programs should inform homeowners about pet waste management on their properties and its effects on local waterways. The plan should indicate which agencies are involved and their specific roles." (MDE Bacteria 2014). The pet waste management program will address homeowner education on proper pet waste management and the damage to stream health caused by pet waste. Viable options for completing this objective include:

- Working with MDE on its Scoop the Poop program
    - MDE (via personal communication with the County's Office of Sustainability and Environmental Resources) is very interested in working to lower pet waste in the state with the Scoop the Poop program. MDE is interested in our proposed sampling effort and may be able to help with outreach efforts and campaigning. This includes development of graphics, magnets with county-specific mascots, and bone-shaped doggy bag holders which can be attached to a leash.
- Creating a Google Map that shows the locations of pet waste stations in communities (VA DEQ, 2011)
- Identifying agencies/offices, community associations, non-profits, and interested members of the community for assistance in this educational program.

EXPANDED PET WASTE EDUCATION

Swann (1999) conducted a study on pet waste education and determined that to reach the highest percentage of the population possible, education should be based on a variety of media. To encourage pet owners to clean up after their pets, PSAs in newspaper, radio, and television would complement awareness messages being spread on the County's website and its social media accounts. Brochures could also augment the educational effort. In addition to the aware message campaign, the County has the following options:

- Installing pet waste stations in residential areas. Pet waste stations should be located in areas that most likely have a high traffic of pet walkers; this specifically includes high density residential areas as identified with GIS land use maps
- Appointing a Lead Coordinator who will be responsible for pet waste station and biodegradable bag orders, assembly and installation of stations, station maintenance, and outreach (VA DEQ, 2011)

Addressing pet waste is crucial in order for total bacteria counts to lower in the County's waterways. Therefore it is best for the County to use all of the above measures in a concentrated effort that includes the County, park workers, police, schools, any interested non-governmental associations, and volunteers. By using all outreach methods available, we can assume maximum awareness percentage (45%) and maximum behavior change (56%), resulting in 25% program efficiency (VADEQ 2013).

SILT FENCES

When a vegetated buffer is not possible, silt fences can be installed. Locations for silt fences are identified by pin-pointing sources of erosion in watersheds and intersecting those locations with impermeable areas. Although not as efficient as riparian buffers, silt fences lower the rate of *E. coli* entering water bodies and prevent high peaks in *E. coli* counts after storm events (EPA Office of Water, 2012). While Erosion and Sediment Control may not appear to be related to *E. coli* loads in waters, the reasoning behind this is scientifically supported. Erosion and sediment control do factor into water bacteria counts, since erosion into water sources can bring with it bacteria that otherwise would not have contaminated the source (Pachepsky, Y. A. and Shelton, D. R., 2011).

WILDLIFE SOURCE ELIMINATION

According to MDE in the E. coli TMDL for Double Pipe Creek, "Neither Maryland nor EPA is proposing the wildlife controls to allow for the attainment of water quality standards, although managing the overpopulation of wildlife remains an option for state and local stakeholders" (MDE DP 2009); however the SW-WLAs include wildlife sources and are impossible to meet without wildlife management. In its guidance for bacteria TMDLs (MDE Bacteria 2014), MDE states that:

> *The plan should address vector control (i.e., limiting animal populations that transmit disease pathogens) associated with garbage (rats), animal control issues like raccoons, resident geese populations, and where appropriate the management of deer populations. For instance, poor trash handling (i.e., not putting trash bags in cans, etc.) often attracts wildlife (e.g., rats, raccoons, and deer) and encourages these animals to stay permanently. This results in unintended population explosions in the urban/developed sector.*

WILD DEER POPULATION CONTROL

Deer are severely overpopulated due to a loss of natural predators, and cause multiple environmental problems to include the loss of plant understory and fecal matter contamination. Though the TMDL focuses primarily on human sources, deer feces was confirmed to be the source of an *E. coli* outbreak in strawberries in Oregon in 2011. *E. coli* in deer feces can persist in the environment. A study by Andrey Guber et al (2014) showed an increase of bacteria growth of 1.5-3 orders of magnitude within the first 4-8 days of deer droppings, and a rate of die-off which still showed active populations 32 days later. Other studies involving leaf splash of fecal material have shown survival up to 177 days. Guber et al. found that deer pellets have an erodibility similar to cow manure disks, which are easily eroded by rain. Substantial studies exist showing the transport of bacteria from cow manure, so the results may be extrapolable. Deer produce an average of 15 pounds manure per 1000 pounds of animal mass per day according to *Population Density Estimates and Fecal Production Rates* by Lucas Gregory. MDE cited 5.00E+08 counts per deer per day in its TMDL for Shellfish in the Lower Patuxent (MDE PAX 2004) using USEPA (2000). That amounts to 182.5 billion CFUs per year. The load to the stream would be affected by transport processes on the surface.

In Frederick County, the Doe Harvest Challenge, run by Farmers and Hunters Feeding the Hungry (FHFH), helps to control deer populations. This is an annual competition. While the program is aimed at feeding the hungry, decreasing crop damage, and keeping deer off of roads, this also lowers wildlife sources of fecal bacteria. Participation is free and unlimited, and hunters receive a Doe Harvest Challenge card for each donated doe. In 2012, this resulted in 3,205 donated deer which resulted in 600,000+ meals in food banks, soup kitchens, and churches in the State of Maryland (Frederick County News Release, 2013).

Throughout the year, two Frederick County butchers, Clint's Cuts and Shuff's Meat Market, participate in FHFH, which is a nonprofit that provides venison to the hungry (MarylandBucks.com). Legally harvested deer can be donated for free at any FHFH donation centers, although meat must be clean, field-dressed deer weighing more than 70 lbs (The Gazette 2009). Future plans should attempt to quantify the MPN in deer feces in order to estimate the benefit of this program on *E. coli* removal.

STORMWATER SOURCE ELIMINATION

MDE states in its bacteria TMDL guidance (MDE Bacteria 2014) that:

> *The plan should indicate that both structural and non-structural Best Management Practices (BMPs) will be constructed and implemented to treat currently untreated stormwater runoff (i.e., retrofits), in order to reduce bacteria loads. Load reductions from these BMPs should then be estimated. The BMP efficiency rates, however, need to be scientifically defensible. The plan should also account for stormwater BMPs which are expected to increase bacteria loads.*

Stormwater management practices used by the County include bioretention, wet ponds, wetlands, bioswales, filters, and reforestation on previous urban surfaces. The WTM includes standard efficiencies for stormwater retrofit practices. Load reductions for wet ponds, wetlands, and filters were not changed from the number given in the WTM. Scenarios for the WTM for structural stormwater management retrofits come from BayFAST models for each local watershed for the TMDLs for sediment and phosphorus.

BIORETENTION/BIOFILTRATION PONDS/ BIOSWALES

Hunt et al. (2008) found the bacteria removal efficiency of bioretention practices to be 70%. The manner in which the County implements bioswales fits with the Watershed Treatment Model's definition of a bioretention practice; therefore bioswale was given a 70% reduction as well.

RIPARIAN BUFFERS

As discussed in previous sections, streamside buffers have proven to successfully lower total bacterial counts in water. This is largely due to erosion prevention. *E. coli* can bind to sediment, which then either stays in the ground or falls into the body of water and increases the total bacterial load (Dr. Muruleedhara Byappanahalli, USGS, personal contact on 4/18/2016). Buffers that prevent erosion therefore can prevent high peaks of bacterial counts after storm events. Even at different water intensities, buffers have proven to reduce up to 83% of fecal coliform

(Royce et al. 1994). The amount of bacteria removed depends on a variety of factors such as bank slope, soil type, size of buffer, vegetation used, and if there is presence of bacteria (Dr. Byappanahalli, personal contact on 4/18/2016). Forest buffer efficiency for bacteria was found to be 42% in a study by Parajuli et al. (2008) and is used in the WTM as an efficiency for riparian buffers as a stormwater retrofit technique.

> *Riparian buffer zones are vegetated areas along streams to reduce erosion, sedimentation, and pollution of water (US EPA 2012a). Densely vegetative cover removes pollutants through detention of runoff, filtration by the vegetation, and infiltration into soil (Boyer ND). The effectiveness of buffers for reducing bacteria pollution, however, is dependent on the type of vegetation and the width of the buffer. Typically, the wider the buffer, the more pollution is reduced. The VA DEQ Guide reports a bacteria removal efficiency of 43-57% (VA DECR and VA DEQ 2003). (Balt Co 2014)*

The County can use an educational program to promote the use and maintenance of buffers in order to lower *E. coli* counts in its waters. This program should utilize as many media forms as possible to include television as well as include educational workshops. Buffer enhancement, tree and shrub planting and maintenance, and native vegetation promotion should be taught and advertised as best management practices that members of the public can use. By using this program the WTM was run with a 0.9 maintenance factor in Riparian Buffers in the Future Management Section for all model runs beginning with the Programmed scenario.

BMP RESEARCH COMPLETED BY BALTIMORE COUNTY

Baltimore County's TMDL Implementation Plan: Bacteria in Herring Run contains a number of BMP citations that were discovered after the restoration scenarios for this report were written. The research for this plan is excellent. The following sections describe these BMP citations and will be considered in future Annual Report updates to this Plan.

DRY DETENTION PONDS

> *Dry detention ponds are basins whose outlets have been designed to detain stormwater runoff for some minimum time (e.g., 24 hours) to allow particles and associated pollutants to settle. They do not have a large permanent pool of water but are often designed with small pools at the inlet and outlet of the basin or can be completely dry between precipitation events (Hathaway et al. 2009; US EPA 2012a). The primary pollutant removal mechanisms are sedimentation, drying, and sun exposure (Hathaway et al. 2009). Studies show detention ponds have a bacteria removal efficiency of 25% (VA DECR and VA DEQ 2003). (Balt Co 2014)*

GRASS SWALES

> *Grass swales are vegetated open channels designed to treat stormwater runoff by slowing the water to allow sedimentation and filtering as the water flows along these channels. Grass swales are typically located along roads because they are linear. They*

should be sited on relatively flat sites as steep slopes encourage erosion. Grass swales typically do not have a high efficiency of bacteria removal, in fact several studies have shown a negative bacteria removal efficiency (- 50%) which indicates more bacteria left the system than entered (US EPA 2012a). This may be because swales are attractive to animals and are not necessarily intended to completely dry between storms, potentially providing an environment where pathogens can persist (Hathaway and Hunt 2008). (Balt Co 2014)

INFILTRATION BASIN

An infiltration basin is a shallow vegetated open impoundment where incoming stormwater runoff is stored until it gradually infiltrates into the soil. Runoff enters the basin and bacteria are removed through detention and filtration. Limitations include the need for permeable soils to reduce the potential for clogging and the need for regular maintenance. The VA DEQ Guidance Manual cites infiltration basins can provide 50% bacteria removal efficiency (VA DECR and VA DEQ 2003). (Balt Co 2014)

INFILTRATION TRENCH

An infiltration trench is an excavated trench that has been lined with filter fabric and backfilled with stone to form an underground basin or reservoir (Boyer Year Unknown; VA DECR and VA DEQ 2003). Stormwater runoff is directed into the trench through the use of grass areas or pretreatment devices. Trenches tend to be more suitable for ultra-urban situations, where the soil has low permeability (Boyer Year Unknown). The VA DEQ Guidance Manual cites infiltration trenches can provide 50% bacteria removal efficiency (VA DECR and VA DEQ 2003). (Balt Co 2014)

POROUS PAVEMENT

Porous or pervious pavement allows rainfall to percolate through it to the subbase, providing storage and enhancing soil infiltration that can be used to reduce runoff and combined sewer overflows. The water stored in the subbase then gradually infiltrates the subsoil (VA DECR and VA DEQ 2003). According to the VA DEQ Guidance Manual (2003), porous pavement can provide 50% bacteria removal efficiency. (Balt Co 2014)

RETENTION PONDS/ WET PONDS

Retention ponds/wet ponds are basins where influent runoff enters the pond and theoretically replaces captured runoff from prior events (the principle of plug flow) (Hathaway et al. 2009). The wet pond retains the runoff for 1-2 days and then slowly drains (Hathaway and Hunt 2008). Bacteria removal is facilitated through settling (sedimentation), plant uptake and sun exposure (Hathaway et al. 2009; Hathaway and Hunt 2008). According to Emmons and Olivier Resources, Inc. and the EPA, literature *review studies cite average bacteria removal rates of 65- 70% (Tilman et al. 2011; US EPA 2012a).Wetland Treatment Systems Research studies found average measured bacteria removal efficiencies for wetland systems of 79% (Tilman et al. 2011). (Balt Co 2014)*

SAND FILTERS

Sand filters are a storm water treatment practice designed to remove sediment and pollutants from the first flush of runoff from pavement and impervious areas after a rain or storm event (Boyer ND). Runoff first enters a sedimentation chamber before flowing through a column of soil. Sand chamber is dry between events. Treatment mechanisms relevant to pathogen removal include drying, sedimentation and filtration (Hathaway and Hunt 2008). Stormwater Best Management practices database (2010) indicated that sand filters are effective in removing from 36 to 83% of the bacteria in urban runoff. (Balt Co 2014)

STREAM BANK STABILIZATION

Waterways that are being eroded can be stabilized by constructing bulkheads, using riprap, gabion systems or establishing vegetation which can reduce the amount of bacteria, nutrients, and sediment from entering the waterway (VA DECR and VA DEQ 2003). Stream bank protection and stabilization can provide for 40-75% bacteria removal efficiency (40% without fencing and 75% with fencing) (VA DECR and VA DEQ 2003). (Balt Co 2014)

STREET SWEEPING

There are three types of street sweepers commonly used: mechanical, vacuum-assisted, and regenerative air (US DOI 2002). The most common type of sweeper, the mechanical sweeper, lifts dirt off the street by a rotating broom and feeds it to a hopper by a conveyor system. A water spray is often used to control dust. Vacuum-assisted sweepers combine a mechanical sweeper with a high-power vacuum. Some use a water spray to control dust. Regenerative-air sweepers combine a mechanical sweeper to loosen dirt with forced air to dislodge the remaining dirt. Street sweeping frequency is an important variable in the effectiveness of removing contaminants (US DOI 2002). For example, sweeping the street at least once between storms is important to remove contaminants before they are washed away by storms. Removal efficiencies are highest for suspended solids, intermediate for removal of lead, and lowest for fecal coliform bacteria and total phosphorus (US DOI 2002). Multiple passes with the street sweeper and the speed of the street sweeper also can affect the removal capabilities. Simulation models developed by USGS show a fecal coliform removal efficiency of 1.3-5.3%, depending on sweeping frequency and land use (US DOI 2002). (Balt Co 2014)

WETLAND TREATMENT SYSTEMS

> *Wetland treatment systems consist of a wetland constructed with the purpose of treating wastewater or stormwater inputs. The wetlands may be vegetated, open water, or a combination (Tilman et al. 2011). These BMPs promote sedimentation like wet ponds, but provide more exposure of captured stormwater to wetland soils and plants in a shallow system (Hathaway et al. 2009). Sun exposure in the open areas and natural die-off are thought to reduce the bacteria population (Tilman et al. 2011). Research studies found average measured bacteria removal efficiencies for wetland systems of 79% (Tilman et al. 2011). The level of bacteria reduction has been shown to increase as the treatment time (e.g., longer than 1-2 days) increases (Khatiwada and Polprasert 1999). (Balt Co 2014)*

BMPS FOR FUTURE CONSIDERATION

HUMAN SOURCES: TRANSIENT HUMAN POPULATIONS

MDE recommends jurisdictions to address areas that have frequent homeless population visits and public areas without sanitary facilities. MDE (MDE Bacteria 2014) prescribes working with non-governmental organizations, the health department, police, and schools to develop surveys that can be part of an educational outreach program; however the WTM does not take into account educational outreach on health concerns of bacteria in regards to public areas and the homeless.

A comprehensive human source control educational program could include many interested parties working in concert to increase public knowledge of human waste problems in the County. Surveys on areas that are known to be frequented by the homeless could be given out to professionals who have this information, including the police department, health department, and schools. After identifying areas of high traffic, the installation of public restrooms, portable toilets, and/or outreach material on human waste issues could be implemented in identified areas of concern. This would be in conjunction with a County-wide public educational program which should be multimedia based. The County may use television, radio and newspaper public service announcements (PSAs), pamphlets in local stores that volunteer to participate, and County web-pages and social media accounts to ensure the maximum possible percentage of public members are reached. The ability to execute such a program at the current time is low.

WILDLIFE SOURCES: CANADA GOOSE ABATEMENT

MDE's bacteria TMDL guidance (MDE Bacterial 2014) states that:

> *poorly vegetated or poorly maintained stormwater management ponds often attract resident geese populations. These factors lead to an increase in bacterial pollution entering nearby waterways. Even though the direct control of these sources does not necessarily fall under the purview of the MS4, bacteria from these sources is transported through the MS4 stormwater collection system to receiving waterbodies.*

Since non-migratory Canada goose (*Branta Canadensis*) populations often return to nesting areas or relocate nearby unless moved at least 200 miles away (French and Parkhurst 2009), techniques that remove significant numbers of geese or prevent them from entering a specific area that is crucial to water conservation should be focused on. The County could start with a list of techniques and identify which ones work best. From French and Parkhurst (2009), unless otherwise noted, these include:

- Husbandry controls
  - Planting species that are less palatable to geese, such as periwinkle, myrtle, pachysandra, English ivy, hosta (plantain lily), and ground junipers
  - Prohibit supplemental feeding of geese, as this promotes continuous congregations of geese in the feeding area
- Non-Lethal Methods
  - Visually frightening devices that resemble scarecrows, owl effigies, or rubber snakes
  - Poles covered with mylar reflective tape, which captures sunlight glare and scares off geese
- Lethal Methods
  - Recreational hunting
  - Oiling or puncturing eggs
- Capture
  - During summer molt, when geese are flightless, geese may be rounded up and captured
    - This is a promising practice not only because the geese are flightless but since most complaints about geese occur in spring and summer (Cooper 1998)
    - Temporary barriers such as fences made of wood, wire, rope, or bird-scare tape can be used to enclose and entrap flightless geese
    - Other programs have had success in capturing geese for processing and human consumption (Cooper 1998)

Multiple methods may prove to be useful components of a full goose removal/control program. Quantifying the effects of a goose removal program could be based on each adult goose producing up to 1.5 lbs (680.4g) of fecal matter per day (French and Parkhurst, 2009). According to Alderisio and DeLuca (1999), Canada Goose feces contains average concentration of fecal coliform bacteria per gram of 1.53×10^4; furthermore, "fecal sample weights collected from 171 geese ranged from 0.44 to 25.4 g, with a mean of 8.35 g per goose fecal sample." The number of CFU per goose per year is estimated to be: 680.4g/25.4g * 1.53×10^4 *365, or 149,544,244.

In addition, public education in the form of signs and brochures at parks and areas of recreation would help strengthen community understanding of wildlife waste and the problems it creates for County waterways. The public should be aware of the program's goals (the improvement of water quality and therefore water ecosystems via reduction of wildlife waste sources). The public should also know this Plan does not call for the removal of the entire Canada goose population. Canada goose removal is of lower priority because the coliform source is less concerning than human sources, and because the level of effort required for bacteria removal is not the most efficient.

DOMESTIC PET SOURCES: HOBBY LIVESTOCK FENCING AND RETIREMENT

According to the WTM user guide, reductions of bacteria are calculated on a per-animal removal basis for livestock. Livestock are not included in the SW-WLAs for any TMDLs; however it is known that residential properties in the watershed often have hobby livestock, to include chickens, horses, and even cattle. An estimate of the number of hobby livestock is not possible, as they are not tracked in the ag census; however elimination of these livestock or reduction of their exposure to runoff has a calculable reduction in the WTM. Dairy cattle, for example, are estimated in the WTM to have a 100% exposure to runoff with a bacteria load of 2,000 billions of organisms per year. There is currently no mechanism to address hobby livestock, but the challenges posed by these animals due to overgrazing/bank trampling and stormwater exposure to fecal material should be considered.

EXPANDED COVER CROPS

There is literature supporting the use of crops and vegetative strips to lower the total counts of fecal coliform in nearby waterways. R.A. Young et al. (1979) quantified the effectiveness of vegetative (crop) buffer strips in controlling pollution from feedlot runoff on a 4% slope. Overall runoff was reduced by 67% by crop buffer strips, and an overall reduction in coliform organisms also occurred. Crop buffer strips lowered the total solids transported by 79%, which would also reduce the number of solids that fecal coliform can bind to and use to reach water bodies. Larsen et al (1994) quantified the reduction in fecal coliform transport from manure to the edge of plots at 83% with the addition of 2 foot-long grass sod filter strips. Bacterial transport was not significantly changed by the rain intensities tested.

Natural Predators of E.coli

"Grazing by bacterivorous protozoa, bacteriophage infection followed by virus-mediated lysis, and predation by some bacteria are among the biotic effects that control the abundance of prokaryotic organisms in the environment. … Bacteriophage infection affects a much wider range of bacteria, and viral infection was suggested to be a mechanism responsible for the elimination of up to 50% of autochthonous bacteria from aquatic habitats …Some estimates suggest that protozoan grazing is responsible for up to 90% of the overall mortality of both autochthonous and allochthonous microorganisms from freshwater and marine environments (Byappanahalli et. al. 2012)

The County could institute a program of installing and maintaining narrow filter strips in areas where practices that require more space are not feasible. This could be especially impactful in rural areas with hobby farms, since farming conditions were used in Larsen et al. (1994) The County could develop an educational program aimed at rural areas and areas known to have hobby farms, or an incentive program for private residences to develop and maintain narrow filter strips may be pursued. This intriguing potential future scenario would include identifying total number of acres of crops and sod strips being used for this purpose, and an 83% reduction rate for *E. coli* could be used.

STREAM AND NEAR BANK STABILIZATION

E. coli is found in stormwater, and is associated with erosion from land uses because "particulate matter (PM) in runoff serves as a substrate and generates a shielding mechanism for these organisms" (Dickenson 2012). Perhaps more important than the load coming from the land surface, during storm events the near-bank floodplain, streambank, and stream bottom are significant sources of *E. coli* attached to sediment. Though the WTM does not provide a bacteria reduction credit from stream restoration or near-bank sediment management, it does provide one from stream stabilization. This credit is likely too small. A growing body of research shows the importance of stream stabilization as an important tool for *E. coli* reduction in streams impacted by stormwater.

- Byappanahalli et al. (2012) notes that "enterococci may be present in high densities in the absence of obvious fecal sources and that environmental reservoirs of these FIB are important sources and sinks, with the potential to impact water quality". Byappanahalli et al. (2003) found that "median *E. coli* counts were highest in stream sediments, followed by bank sediments, sediments along spring margins, stream water, and isolated pools. This study found "significant correlations between *E. coli* numbers in stream water and stream sediment, submerged sediment and margin, and margin and 1 m from shore" in a small coastal stream in Michigan. The study concluded that *E. coli* in riparian sediment can be both a source and sink of chronically high levels of the bacteria seen in the water column.

- Davies et. al. (2015) found that *E. coli* can be persistent when attached to wet sediment, even to TSS in the water column. They conducted an experiment to look at bacteria survival over time and determined that "throughout the duration of the experiment (68 days), the same proportion of *E. coli* organisms remained culturable, suggesting that sediment provides a favorable, nonstarvation environment for the bacteria."
- *E. coli* is preferentially transported in the water column by specific suspended sediment particle sizes; therefore, modeling tools that address TSS may be able to be modified to address *E.coli* fate and transport. (Qian 2016)

Best management practices which serve to prevent the loss of sediment from various sources including near bank floodplains, stream banks, and stream bottoms will further protect sediment-bound *E.coli* from entering the water column. In personal communication with Dr. Byappanahalli by email, he suggested that populations are not homogenous in the landscape, which makes prediction of reduction from bank controls extremely challenging.

PROTECTING NATURAL PREDATORS OF E. COLI

The persistence of *E. coli* bacteria in wetted sediments may be attributable in part to an upset in natural predation of these bacteria due to the introduction of agricultural chemicals. Staley et al (2014) inhibited natural predation of *E. coli* using several ag chemicals to "isolate the effects of predation or competition on survival of allochthonous bacteria. The result of the experiment was that "each treatment increased the survival of Fecal Indicator Bacteria (FIB) and pathogens. Chlorothalonil's effect was similar to that of cycloheximide, significantly reducing protozoan densities and elevating densities of FIB and pathogens relative to the control. Atrazine treatment did not affect protozoan densities, but, through an effect on competition, resulted in significantly greater densities of En. faecalis and *E. coli* O157:H7. Hence, by reducing predaceous protozoa and bacterial competitors that facilitate purifying water bodies of FIBs and human pathogens, chlorothalonil and atrazine indirectly diminished an ecosystem service of fresh water." In watersheds with combined stormwater and agriculture, decreasing the use of certain ag chemicals could lead to reduced bacteria.

E. COLI PLANS BY WATERSHED

DOUBLE PIPE CREEK WATERSHED

The Maryland Department of the Environment completed monitoring of Double Pipe Creek in 2004. The monitoring data and subsequent analysis showed that the water body was not meeting its designated use criteria due to *E. coli* pollution. According to MDE, the portion of the watershed in Frederick County, sections of Little Pipe Creek and Sam's Creek watersheds, has been designated as Use IV-P (Water Contact Recreation, Protection of Aquatic Life, Recreational Trout Waters and Public Water Supply). MDE developed a TMDL for *E. coli* in Double Pipe Creek in 2009. This TMDL was approved by EPA in 2009. The portion of Double Pipe Creek that is in Frederick County is rural, with its main stormwater inputs from roads and rural residences. There are no sewer lines in this portion of the watershed. Bacterial Source Tracking monitoring "was conducted at six stations throughout the Double Pipe Creek watershed, where 12 samples (one per month) were collected for a one-year duration." (MDE DP 2009). According to MDE, the TMDL is not possible to meet because:

water quality standards cannot be attained in any of the seven Double Pipe Creek subwatersheds, using the MPR scenario. MPRs may not be sufficient in subwatersheds where wildlife is a significant component or where very high reductions of fecal bacteria loads are required to meet water quality standards. In these cases, it is expected that the MPR scenario will be the first stage of TMDL implementation.

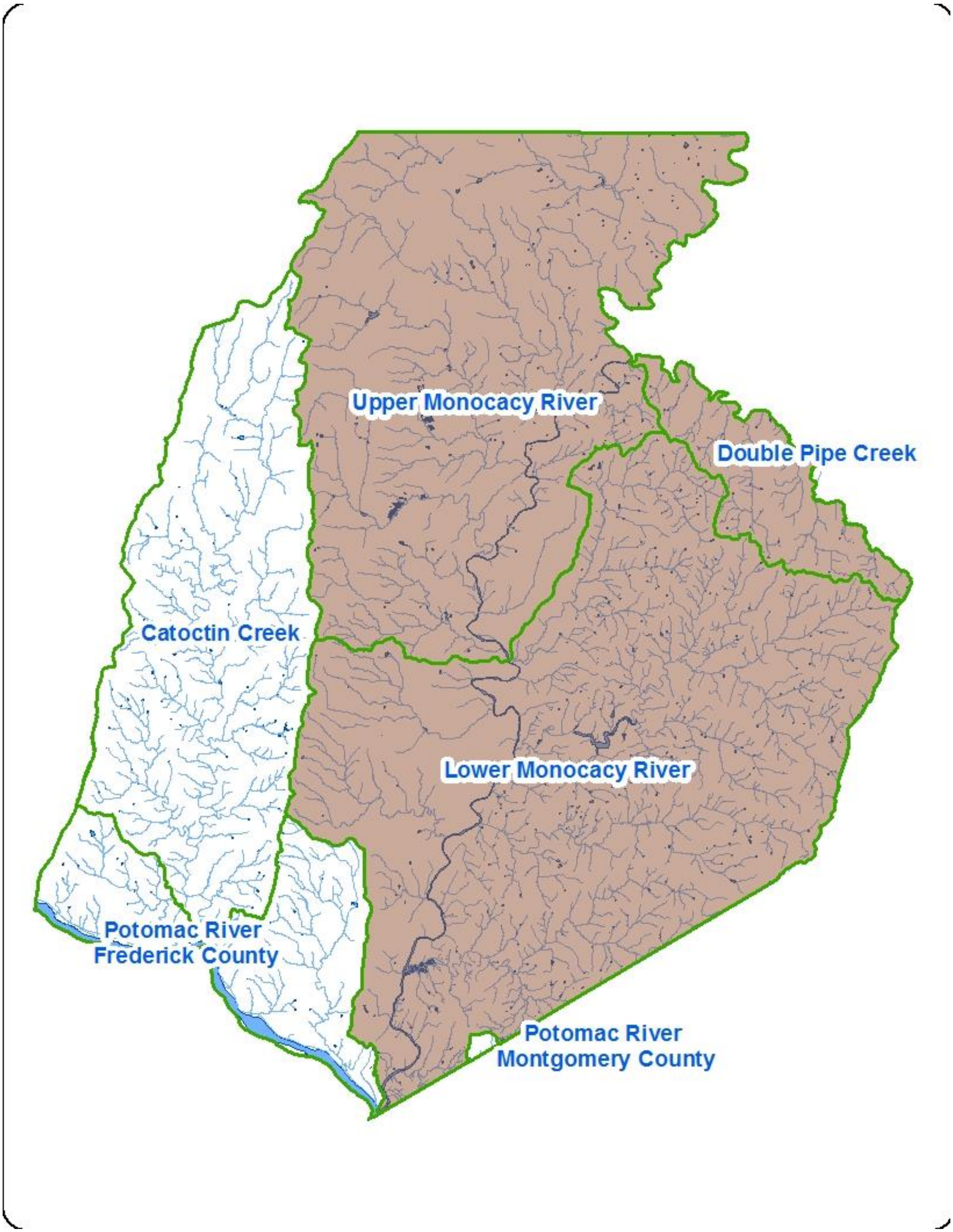
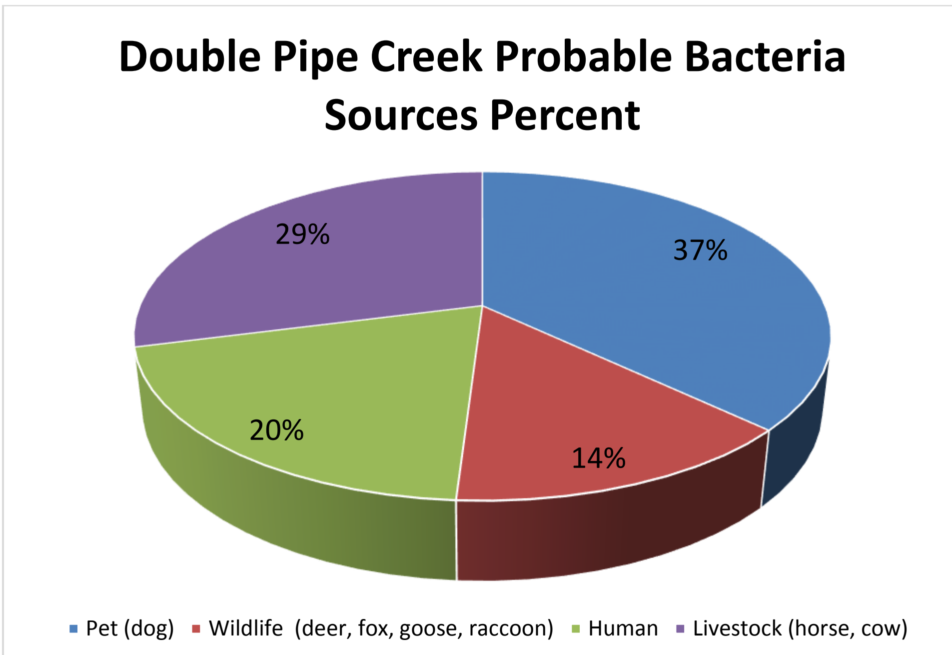


Figure 35: Watershed with *E. coli* TMDLs

For the MPR, MDE (MDE DP 2009) envisions a phased in approach:

> *MDE intends for the required reductions to be implemented in an iterative process that first addresses those sources with the largest impact on water quality and human health risk, with consideration given to ease of implementation and cost. The iterative implementation of BMPs in the watershed has several benefits: tracking of water quality improvements following BMP implementation through follow-up stream monitoring; providing a mechanism for developing public support through periodic updates on BMP implementation; and helping to ensure that the most cost-effective practices are implemented first.*

To determine the MPR for the SW-WLA, a weighted calculation must be performed. Bacteria sources by percent from the BST study included in the TMDL (MDE DP 2009) are shown in the graph below.



Each of these sources has a different MPR and contains loads for different sectors, so a weighted average MPR by source and sector in the SW-WLA is used. The table below shows the derivation of the weighted average MPR.

Table 40: MPR Percent Derivation for Double Pipe Creek based on Weighted Average by Source

Source	MPR By Source	Baseline Sector Load SW-WLA	Weighted SW-WLA MPR
Human	95%	6568.6	80.8%
Domestic	75%	3075.9	
Wildlife	0%	930.1	
Livestock	75%	0	

The table below calculates the target Frederick County MS4 load based on the disaggregated Frederick County MS4 load as reported in the 2015 MS4 Annual Report. This load was calculated using MDE's *Guidance for Developing a Stormwater Wasteload Allocation Implementation Plan for Bacteria Total Maximum Daily Loads* (2014).

Table 41: Bacteria Baseline Loading Estimates for Double Pipe Creek Watershed and Comparison Values from MDE

Parameter	Date	Baseline Frederick County MS4 load	Frederick County Reduction %	Frederick County MS4 Reduction Amount	Target Frederick County MS4 load
Bacteria SW-WLA (*E. coli*)	2004	165,132.7 Billion MPN/year	98.8%	163,151.1 Billion MPN/year	1,981.6 Billion MPN/year
Bacteria MPR (*E. coli*)	2009	165,132.7 Billion MPN/year	80.8%	133,427.2 Billion MPN/year	31,705.5 Billion MPN/year

To meet the Target Frederick County MS4 load for the MPR scenario, and to work towards addressing the load for the SW-WLA, Frederick County built a restoration scenario for the watershed. This scenario was built using multiple model runs of the Watershed Treatment Model version 2013.

Table 42: Results of WTM Modeling Double Pipe Creek Watershed

Scenario	WTM Model Run	Scenario Details	Reduction Amount Billion MPN/year	Reduction %
Baseline	**WTM 1.0 (Primary and Secondary Loads with Existing Management Practices**)	• Calibrated to disaggregated MDE Baseline Load using instructions from MDE.	0	0%
Completed	**WTM 1.0**	• BMP Retrofits from BayFAST Model Run for Completed projects for Phosphorus and Sediment TMDLs in Double Pipe Creek • Septic System repairs, upgrades and retirement in Completed time period (not in BayFAST) • Riparian Buffers in Completed scenario from BayFAST • Land use changes from Land Use BMPs in BayFAST for Completed scenario	2855.98	1.75%
Programmed	**WTM 2.0**	• BayFAST Model Run for Programmed projects in Double Pipe Creek • Septic System repairs, upgrades and retirement in Programmed time period (not in BayFAST) • Riparian Buffers in Programmed scenario from BayFAST • Land use changes from Land Use BMPs in BayFAST for Programmed scenario • Expanded Pet Waste Program • Septic System Denitrification • Riparian Buffer Education	42,979.30	26.03%

		• Septic System Education		
Identified	WTM 3.0	• BayFAST Model Run for Identified projects in Double Pipe Creek • Septic System repairs, upgrades and retirement in Identified time period (not in BayFAST) • Riparian Buffers in Identified scenario from BayFAST • Land use changes from Land Use BMPs in BayFAST for Identified scenario • Expanded Pet Waste Program • Septic System Denitrification • Riparian Buffer Education • Septic System Education	49,410.06	29.92%
Potential	WTM 4.0	• BayFAST Model Run for Potential projects in Double Pipe Creek • Septic System repairs, upgrades and retirement in Potential time period (not in BayFAST) • Riparian Buffers in Potential scenario from BayFAST • Land use changes from Land Use BMPs in BayFAST for Potential scenario • Expanded Pet Waste Program • Septic System Denitrification • Riparian Buffer Education • Septic System Education	165,755.65	100.38%
Cumulative Reduction			**165,755.65**	**100.38%**
MPR EXCEEDED			133,427.2	80.8%
TMDL WLA EXCEEDED			163,151.1	98.8%

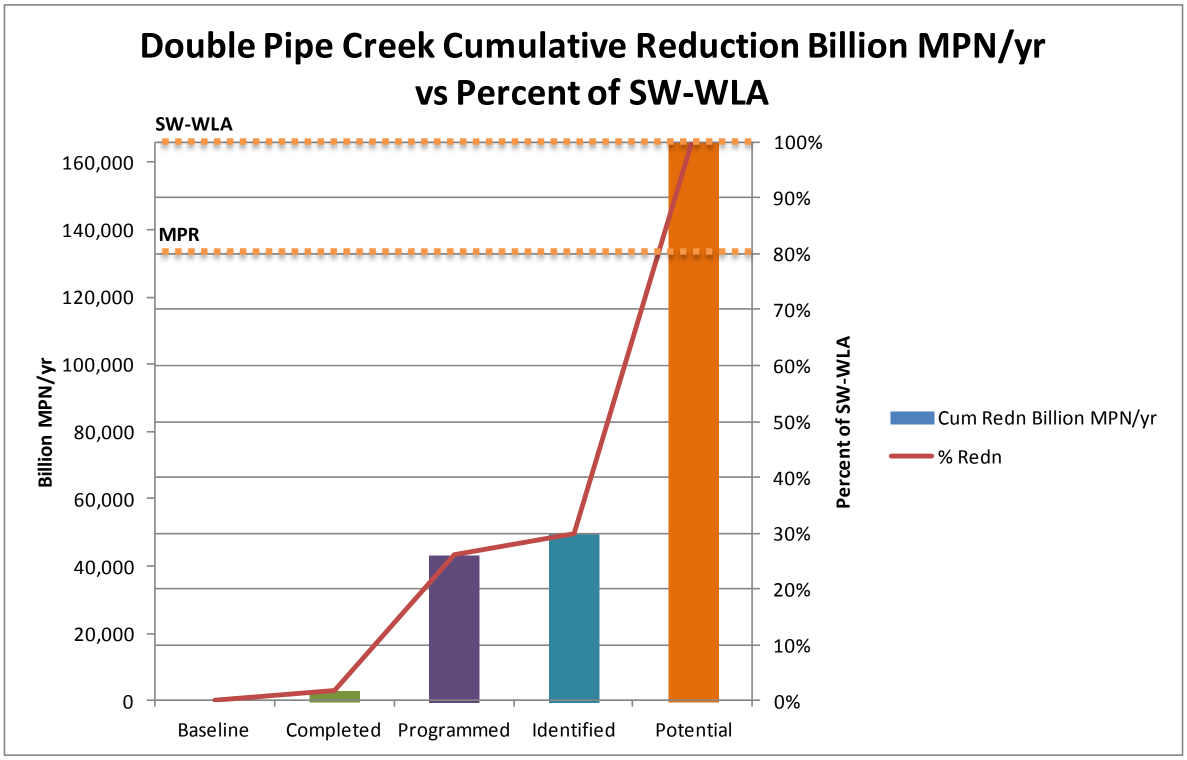


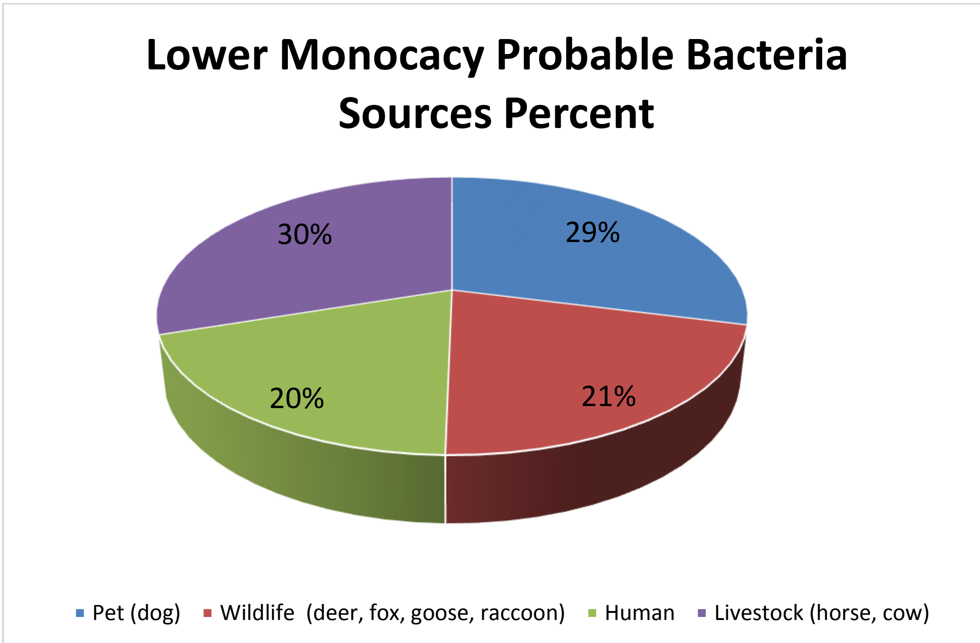
Figure 36: Double Pipe Creek Cumulative Reduction Billion MPN/yr versus Percent of SW-WLA

LOWER MONOCACY WATERSHED

The Maryland Department of the Environment completed monitoring of Lower Monocacy in 2004. The monitoring data and subsequent analysis showed that the water body was not meeting its designated use criteria due to *E. coli* pollution. According to MDE, the Lower Monocacy River upstream of US Route 40 and the tributary Israel Creek are designated as Water Use IV-P (Recreational Trout Waters and Public Water Supply). Downstream of US Route 40, the Lower Monocacy River has a Use I-P designation (Water Contact Recreation, Protection of Aquatic Life and Public Water Supply). Other tributaries such as Carroll Creek, Rocky Fountain Run, Little Bennett Creek, Furnace Branch, Ballenger Creek and Bear Branch are designated as Use III-P water bodies (Non-tidal Cold Water and Public Water Supply).

MDE developed a TMDL for *E. coli* in the Lower Monocacy in 2009. This TMDL was approved by EPA in 2009. The portion of the Lower Monocacy watershed that is in Frederick County covers the city of Frederick and the towns of Walkersville, Woodsboro, and Mount Airy. The watershed's main stormwater inputs are from roads and residences. There are 311.1 miles of sanitary sewer in this portion of the watershed, and only 3% of the dwelling units are unsewered. Bacterial Source Tracking monitoring was conducted at nine stations throughout the Lower Monocacy watershed, and 12 samples (one per month) were collected throughout the duration of one year. Two stations in the Upper Monocacy River basin were included in the TMDL analysis to determine the TMDL for the portion of land not accounted for in the Upper Monocacy TMDL.

As discussed in the TMDL Restoration Plan for *E. coli* in Double Pipe Creek, a Maximum Percent Reduction approach is used for the Lower Monocacy Watershed. To determine the MPR for the SW-WLA, a weighted calculation must be performed. Bacteria sources by percent from the BST study included in the TMDL (MDE LM 2009) are shown in the graph below.



Each of these sources has a different MPR and contains loads for different sectors, so a weighted average MPR by source and sector in the SW-WLA is used. The table below shows the derivation of the weighted average MPR.

Table 43: MPR Percent Derivation for Lower Monocacy based on Weighted Average by Source

Source	MPR By Source	Baseline Sector Load SW-WLA	Weighted SW-WLA MPR
Human	95%	2652.4	76.06%
Domestic	75%	3900.4	
Wildlife	0%	606.4	
Livestock	75%	0	

The table below calculates the target Frederick County MS4 load based on the disaggregated Frederick County MS4 load as reported in the 2015 MS4 Annual Report. This load was calculated using MDE's *Guidance for Developing a Stormwater Wasteload Allocation Implementation Plan for Bacteria Total Maximum Daily Loads* (2014).

Table 44: Bacteria Baseline Loading Estimates for Lower Monocacy Watershed and Comparison Values from MDE

Parameter	*Date*	*Baseline Frederick County MS4 load*	*Frederick County Reduction %*	*Frederick County MS4 Reduction Amount*	*Target Frederick County MS4 load*
Bacteria SW-WLA (*E. coli*)	2004	1,700,789.7 Billion MPN/year	92.5%	1,573,230.4 Billion MPN/year	127,559.2 Billion MPN/year
Bacteria MPR (*E. coli*)	2009	1,700,789.7 Billion MPN/year	76.1%	1,293,620.6 Billion MPN/year	407,169.1 Billion MPN/year

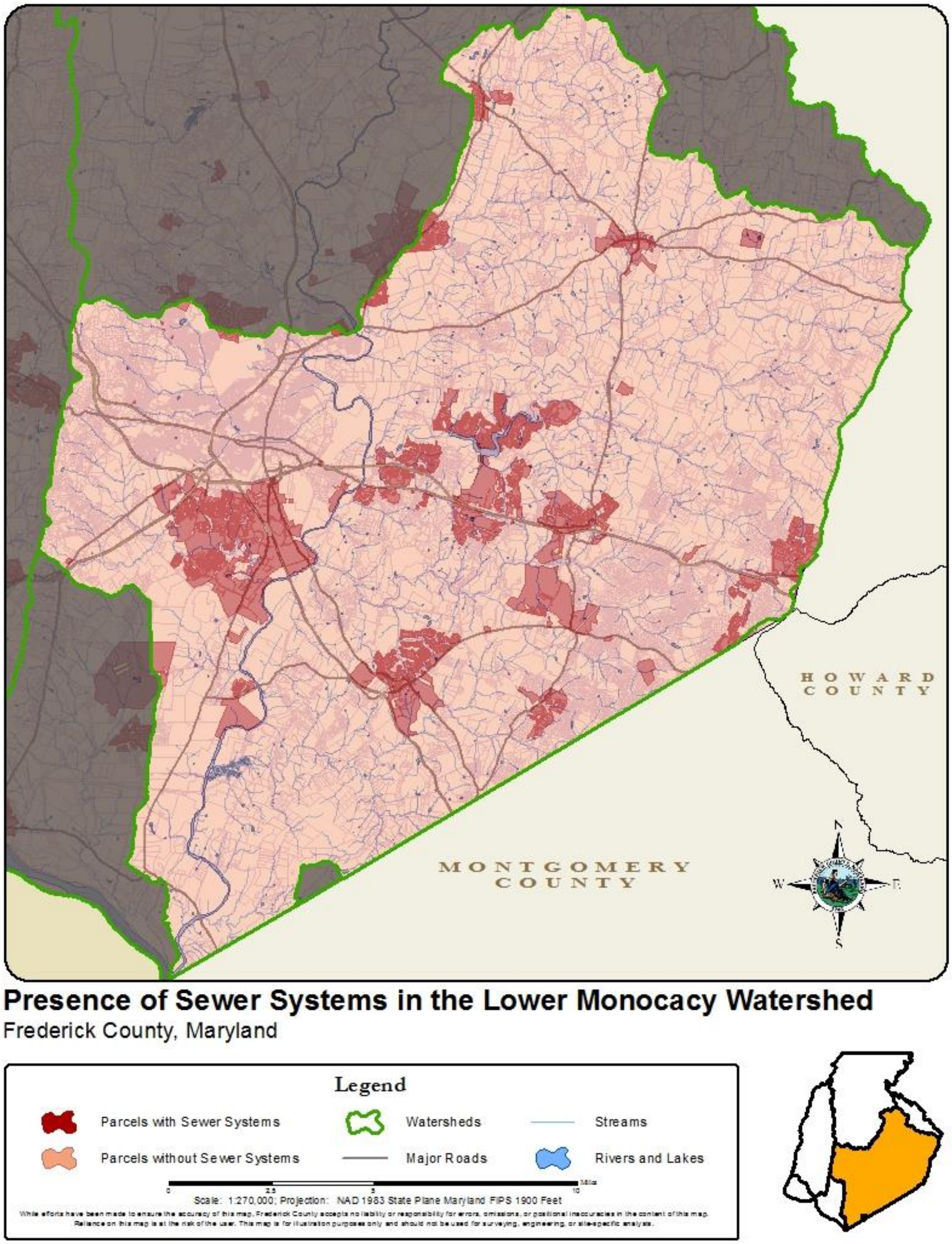


Figure 37: Sanitary Sewershed in the Lower Monocacy Watershed

To meet the Target Frederick County MS4 load for the MPR scenario, and to work towards addressing the load for the SW-WLA, Frederick County built a restoration scenario for the watershed. This scenario was built using multiple model runs of the Watershed Treatment Model version 2013. SSO loads were modeled outside of the WTM model.

The table below explains the elements of each model runs and the corresponding percent reduction of *E. coli.*

Table 22: Results of WTM Modeling Lower Monocacy Watershed

Scenario	WTM Model Run	Scenario Details	Reduction Amount Billion MPN/year	Reduction %
Baseline	**WTM 1.0 (Primary and Secondary Loads with Existing Management Practices**)	• Calibrated to disaggregated MDE Baseline Load using instructions from MDE.	0	0%
Completed	**WTM 1.0**	• BMP Retrofits from BayFAST Model Run for Completed projects for Phosphorus and Sediment TMDLs in Double Pipe Creek • Septic System repairs, upgrades and retirement in Completed time period (not in BayFAST) • Riparian Buffers in Completed scenario from BayFAST • Land use changes from Land Use BMPs in BayFAST for Completed scenario	32,028.4	1.9%
Programmed	**WTM 2.0**	• BayFAST Model Run for Programmed projects in Double Pipe Creek • Septic System repairs, upgrades and retirement in Programmed time period (not in BayFAST) • Riparian Buffers in Programmed scenario from BayFAST • Land use changes from Land Use BMPs in BayFAST for Programmed scenario • Expanded Pet Waste Program • Septic System Denitrification • Riparian Buffer Education • Septic System Education	142,836.3	8.4%
SSO Reductions	**Modeled outside of WTM using data from DUSWM**	• 1,898,574 Billion MPN in baseline (September 2013-November 2014) • 0 load projected by completion of Potential scenario	2,041,410.3	120.0%

Cumulative Reduction	**2,041,410.3**	**120.0%**
MPR EXCEEDED	1,293,620.6	76.1%
TMDL WLA EXCEEDED	1,573,230.4	92.5%

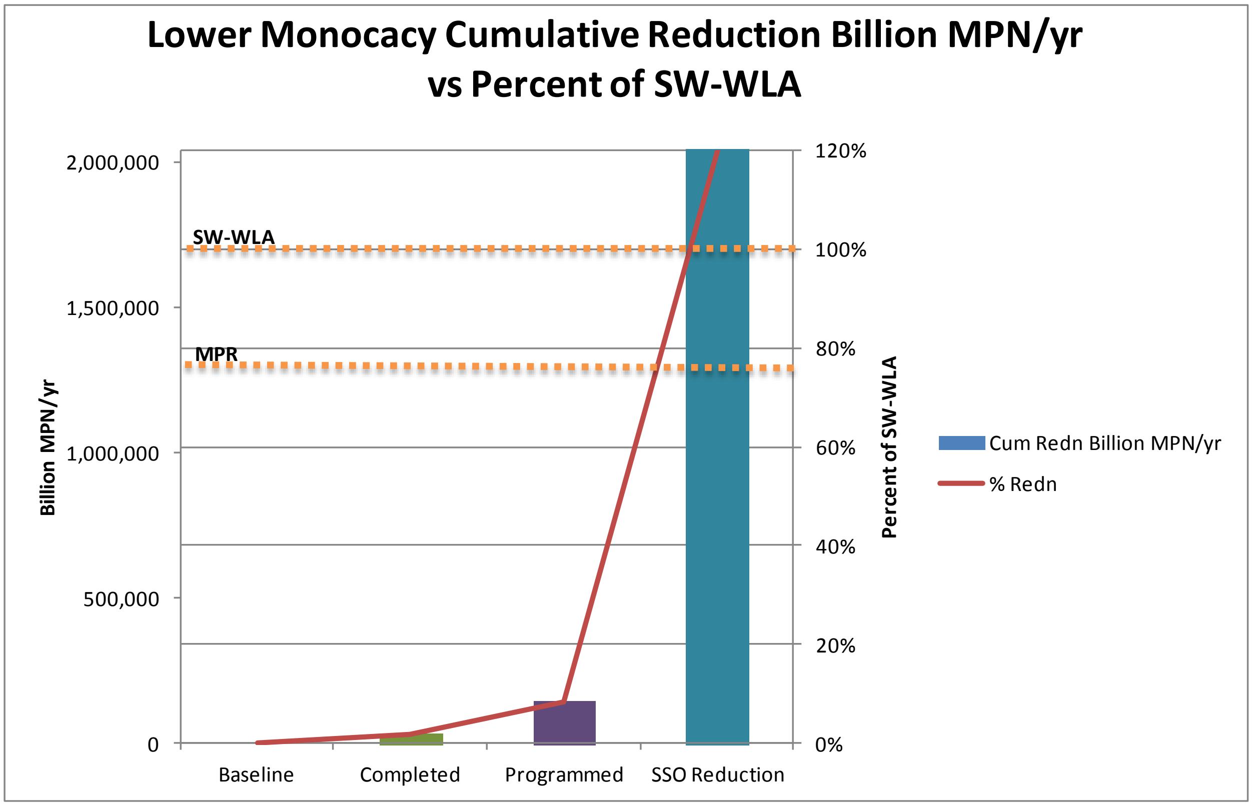


Figure 38: Lower Monocacy Cumulative Reduction Billion MPN/yr versus Percent of SW-WLA

UPPER MONOCACY WATERSHED

The Maryland Department of the Environment completed monitoring of the Upper Monocacy in 2004. The monitoring data and subsequent analysis showed that the water body was not meeting its designated use criteria due to *E. coli* pollution. According to MDE, the mainstream Upper Monocacy River, portions of tributaries Toms Creek and Piney Creek, and the tributary Double Pipe Creek are designated Use IV-P water bodies (Water Contact Recreation, Protection of Aquatic Life, Recreational Trout Waters and Public Water Supply). Use III-P (Water Contact Recreation, Protection of Aquatic Life, Non-tidal Cold Water and Public Water Supply) is designated to the remaining tributaries in MD, which are Tuscarora Creek, Fishing Creek, Hunting Creek, and Owens Creek.

MDE developed a TMDL for *E. coli* in the Upper Monocacy in 2009. This TMDL was approved by EPA in 2009. The portion of the Upper Monocacy watershed that is in Frederick County is mostly rural, with its main stormwater inputs from roads and rural residences. There are 101.3 miles of sanitary sewer lines in this portion of the

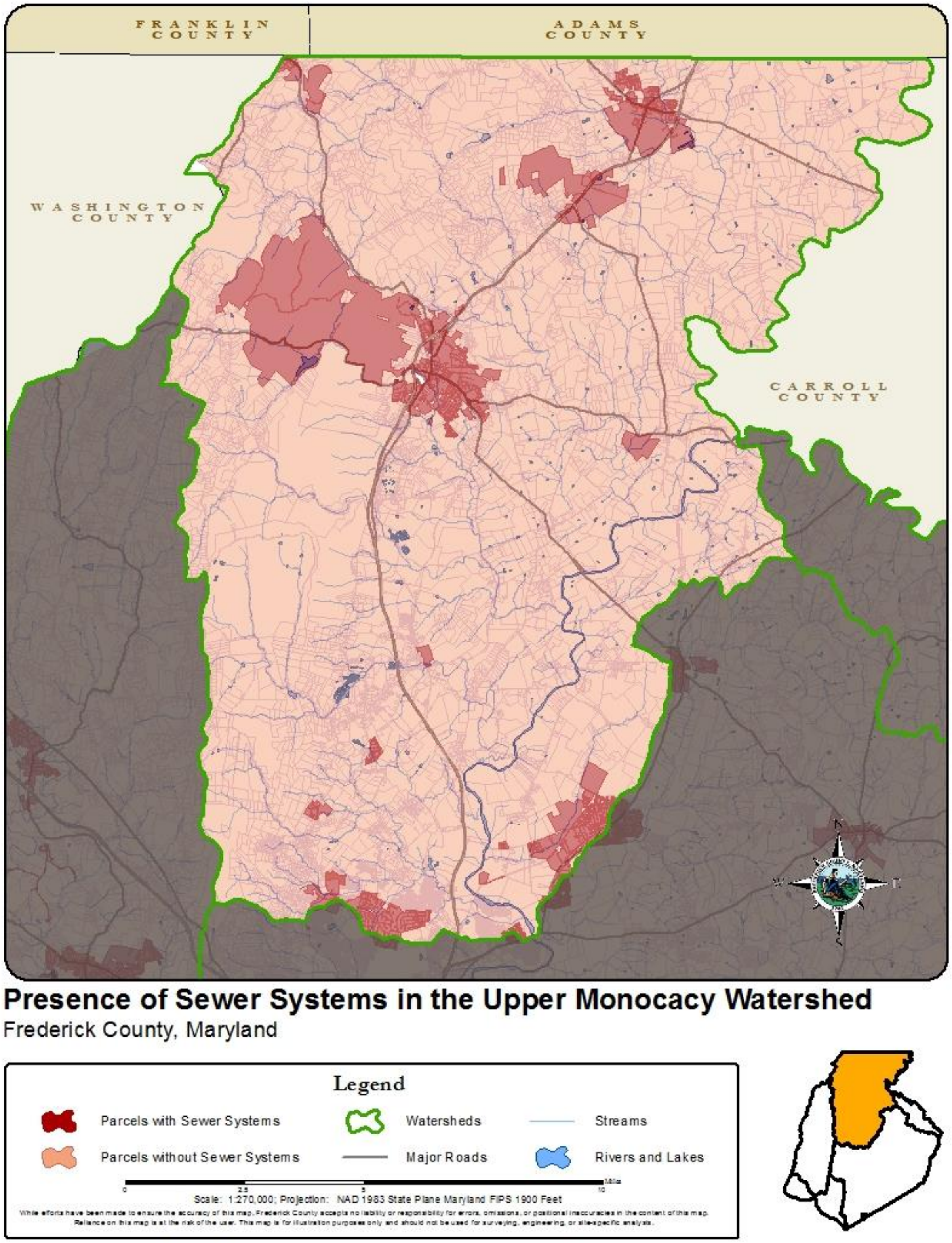


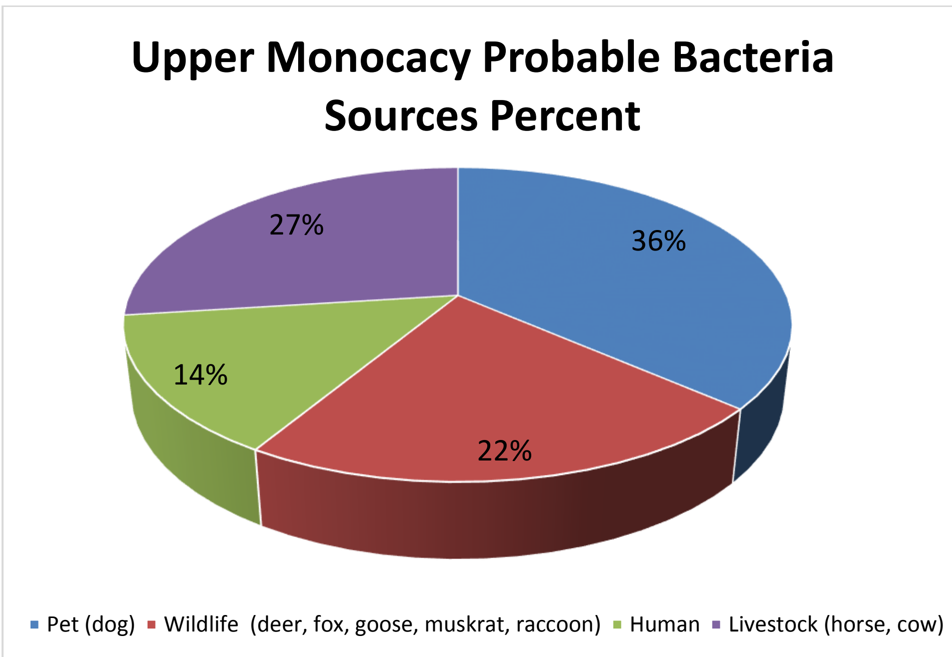
Figure 39: Sanitary Sewershed in the Upper Monocacy River Watershed

watershed, and 33% of dwelling units are unsewered. Bacterial Source Tracking monitoring was conducted once a month for a year (total of 12 times) at nine MDE monitoring stations in the Upper Monocacy watershed. Two additional stations were used to determine the loadings coming from Double Pipe Creek.

As discussed in the TMDL Restoration Plan for *E. coli* in Double Pipe Creek, a Maximum Percent Reduction approach is used for the Lower Monocacy Watershed. To determine the MPR for the SW-WLA, a weighted calculation must be performed. Bacteria sources by percent from the BST study included in the TMDL (MDE LM 2009) are shown in the graph below.

As discussed in the TMDL Restoration Plan for *E. coli* in Double Pipe Creek, a Maximum Percent Reduction approach is used for the Lower Monocacy Watershed. To determine the MPR for the SW-WLA, a weighted

calculation must be performed. Bacteria sources by percent from the BST study included in the TMDL (MDE LM 2009) are shown in the graph below.



Each of these sources has a different MPR and contains loads for different sectors, so a weighted average MPR by source and sector in the SW-WLA is used. The table below shows the derivation of the weighted average MPR.

Table 45: MPR Percent Derivation for Upper Monocacy based on Weighted Average by Source

Source	MPR By Source	Baseline Sector Load SW-WLA	Weighted SW-WLA MPR
Human	95%	3368.2	85.3%
Domestic	75%	943.5	
Wildlife	0%	267.6	
Livestock	75%	0	

The table below calculates the target Frederick County MS4 load based on the disaggregated Frederick County MS4 load as reported in the 2015 MS4 Annual Report. This load was calculated using MDE's *Guidance for Developing a Stormwater Wasteload Allocation Implementation Plan for Bacteria Total Maximum Daily Loads* (2014).

Table 46: Bacteria Baseline Loading Estimates for Upper Monocacy Watershed and Comparison Values from MDE

Parameter	*Date*	*Baseline Frederick County MS4 load*	*Frederick County Reduction %*	*Frederick County MS4 Reduction Amount*	*Target Frederick County MS4 load*
Bacteria SW-WLA (*E. coli*)	2004	867,710.8 Billion MPN/year	97.0%	841,679.4 Billion MPN/year	26,031.3 Billion MPN/year
Bacteria MPR (*E. coli*)	2009	867,710.8 Billion MPN/year	85.3%	740,398.4 Billion MPN/year	127,312.4 Billion MPN/year

Table 47: Results of WTM Modeling Upper Monocacy Watershed

Scenario	WTM Model Run	Scenario Details	Reduction Amount Billion MPN/year	Reduction %
Baseline	**WTM 1.0 (Primary and Secondary Loads with Existing Management Practices)**	• Calibrated to disaggregated MDE Baseline Load using instructions from MDE.	0	0%
Completed	**WTM 1.0**	• BMP Retrofits from BayFAST Model Run for Completed projects for Phosphorus and Sediment TMDLs in Double Pipe Creek • Septic System repairs, upgrades and retirement in Completed time period (not in BayFAST) • Riparian Buffers in Completed scenario from BayFAST • Land use changes from Land Use BMPs in BayFAST for Completed scenario	22,427.0	2.58%
Programmed	**WTM 2.0**	• BayFAST Model Run for Programmed projects in Double Pipe Creek • Septic System repairs, upgrades and retirement in Programmed time period (not in BayFAST) • Riparian Buffers in Programmed scenario from BayFAST • Land use changes from Land Use BMPs in BayFAST for Programmed scenario • Expanded Pet Waste Program • Septic System Denitrification	118,541.6	13.66%

		• Riparian Buffer Education • Septic System Education		
SSO Reductions	**Modeled outside of WTM using data from DUSWM**	• 766,357 Billion MPN in baseline (Note 2005 is used instead of 2003-2004 for baseline in order to capture large SSO.) • 0 load projected by completion of Potential scenario	884,898.6	102.0%
Cumulative Reduction			**884,898.6**	**102.0%**
MPR EXCEEDED			740,398.4	85.3%
TMDL WLA EXCEEDED			841,679.4	97.0%

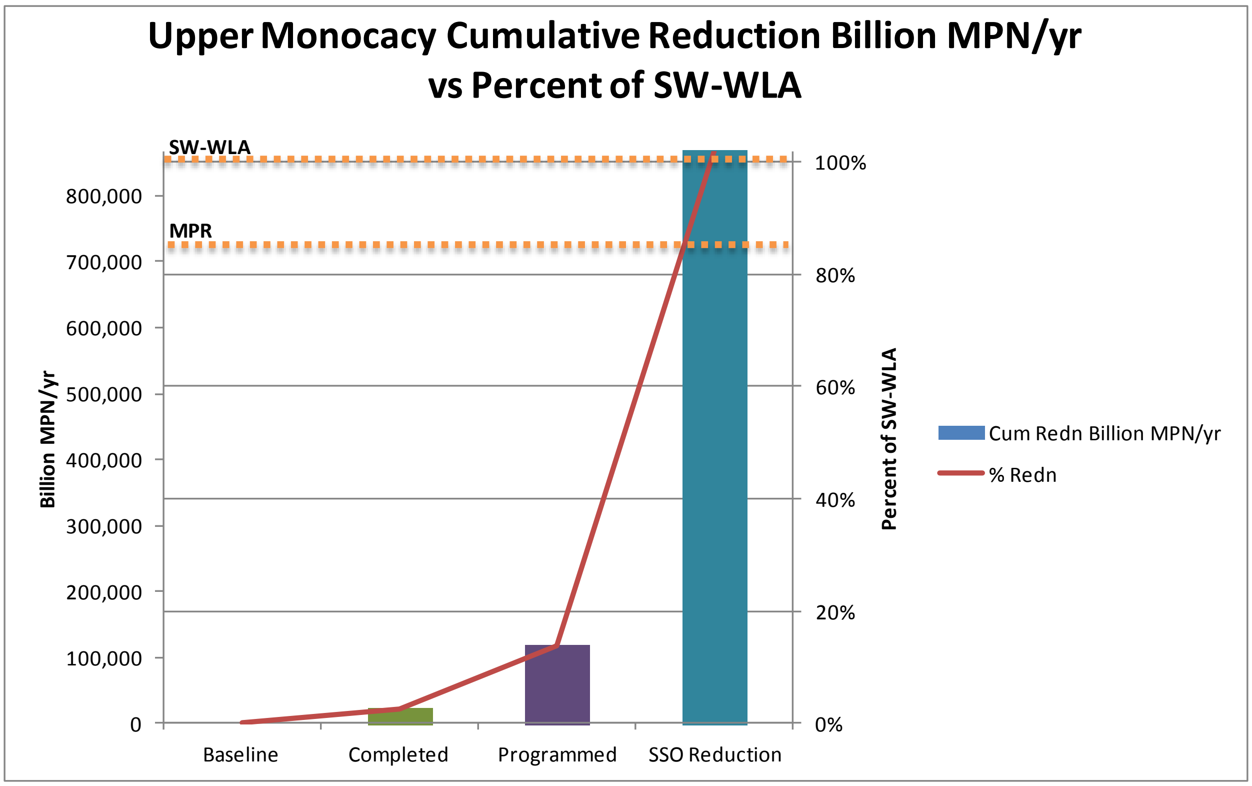


Figure 40: Upper Monocacy Cumulative Reduction Billion MPN/yr versus Percent of SW-WLA

MONITORING AND EVALUATION

With Hood College and the Chesapeake Bay Foundation, the County is selecting sites for *E. coli* testing. The chosen sites will be based on areas with suspect septic tank locations as determined by the Health Department and other areas of potential and confirmed high counts of bacteria. Trails and roads that cross waterways are ideal locations for sampling. Proposed sampling sites as of April 22, 2016 are shown on the following map:

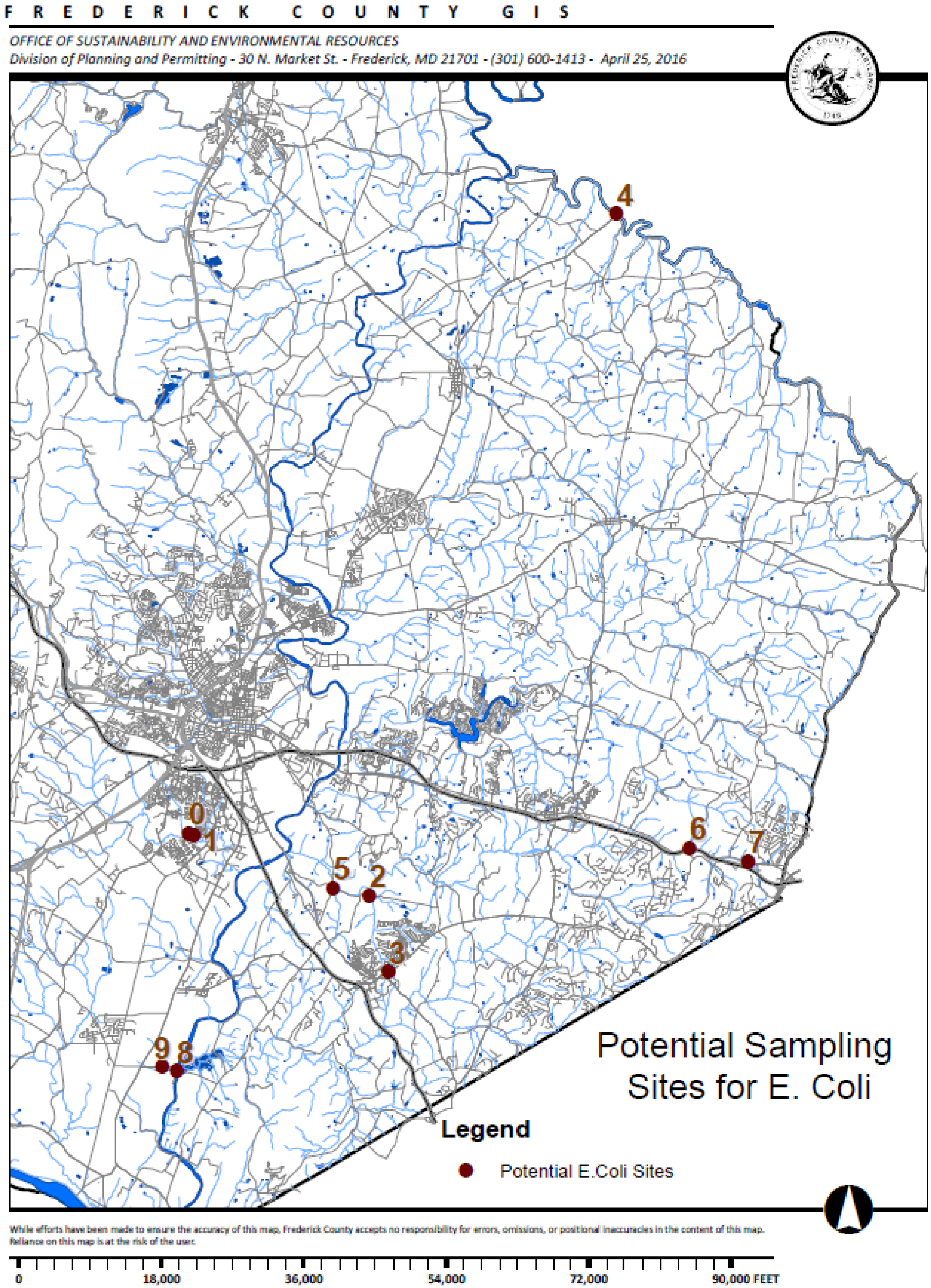


Figure 41: Proposed sampling sites for E. coli in Frederick County as of April 22, 2016

CONCLUSION

The *E. Coli* TMDL SW-WLAs were met in all final scenarios for Double Pipe Creek (1,981.6 Billion MPN/year), Lower Monocacy River (127,559.2 Billion MPN/year), and Upper Monocacy River (26,031.3 Billion MPN/year). In Double Pipe Creek, a reduction amount of 165,755.7 Billion MPN/year was achieved, representing 100.38% of the required reduction. In the Lower Monocacy River, a reduction amount of 3,114,414.1 Billion MPN/year was achieved, representing 183.12% of the required reduction. In the Upper Monocacy River, a reduction amount of 1,137,559.2 Billion MPN/year was achieved, representing 131.1% of the required reduction. Neither the Upper Monocacy nor the Lower Monocacy SW-WLAs could be met without reducing SSOs. Both could be met by the end of the Programmed permit term by including SSO reductions. Double Pipe Creek had no SSOs for Frederick County. All watersheds used a multi-pronged approach that included volumetric practices for stormwater like bioretention and pond retrofits, as well as alternative practices for stormwater like riparian buffer planting and stream restoration that were captured in the BayFAST models for the nutrient and sediment TMDLs; education; septic system practices; and illicit connection removal.

The Upper Monocacy and Lower Monocacy Watershed *E. coli* TMDL SW-WLAs for the MS4 are expected to be met during the current permit term.

Table 48: Summary of SW-WLA *E. coli* Reductions by Watershed

Watershed	Scenario	Reduction Amount Billion MPN/year	% Reduction
Double Pipe Creek	Cumulative Reduction	165,755.7	100.38%
	MPR EXCEEDED	133,427.2	80.8%
	TMDL WLA EXCEEDED	163,151.1	98.8%
Lower Monocacy River	Cumulative Reduction	2,041,410.3	120.0%
	MPR EXCEEDED	1,293,620.6	76.06%
	TMDL WLA EXCEEDED	1,573,230.4	92.5%
Upper Monocacy River	Cumulative Reduction	884,898.6	102.0%
	MPR EXCEEDED	740,398.4	85.3%
	TMDL WLA EXCEEDED	841,679.4	97.0%

SUMMARY PROJECTS, COSTS AND TIMEFRAMES FOR ALL PLANS

Bioretention Facility, Libertytown Park

METHODS

This section describes in detail all of the projects, costs and timeframes that count towards all of the TMDL Restoration Plans as well as the Impervious Cover Restoration Plan. A single master list of projects was developed to meet the Chesapeake Bay TMDL for Nitrogen because all other scenarios nest inside of this TMDL; therefore, the Chesapeake Bay Nitrogen TMDL Restoration Plan drives the overall Stormwater Restoration Plan.

PROJECTS BY RESTORATION TIER

As stated earlier in this document, Restoration Tiers include Baseline, Completed, Programmed, Identified, and Potential scenarios. Baselines are the TMDL loads without restoration Best Management Practices. Completed projects were finished after March 11, 2007, the expiration date of the previous permit and before December 30, 2014, the start date of the current permit. Programmed projects are programmed into the County's Capital Improvement Program and other programs during the permit term, which is set to expire December 30, 2019. Identified projects can be found in Watershed Management Plans, Restoration and Retrofit Assessments, Stormwater Master Plans, and other documents completed by Frederick County Government and its partners and consultants to identify watershed restoration opportunities. Potential Projects are hypothetical projects based on the most cost-effective BMP types and acres of available land. These last two tiers are to be completed after January 1, 2020.

COST ESTIMATES

Cost estimates come from the following sources:

- **Completed** CIP project costs are used where available. When completed costs are not available, Brown and Caldwell's 2014 *Technical Memo 1* is used. This study was prepared under contract to AquaLaw, Frederick County's outside legal counsel on stormwater matters, as part of a review of the County's MEP Analysis. (B&C 2014). Brown and Caldwell made recommendations on costs based on The King and Hagan study (2011) and adjusted dollars of some practices based on their experience with contracting projects in Maryland. They also adjusted cost estimates to FY'17 as the midpoint of the permit.
- **Programmed** estimates come from the programmed CIP budget for FY 2016 through FY 2020. These represent engineering cost estimates at a 10-30% design phase. Tree planting and easement acquisition program costs come from Brown and Caldwell 2014.
- **Identified** and **Potential** scenarios use costs from Brown and Caldwell 2014.
- Management program costs for *E. coli* are absorbed by the operating budget for the NPDES MS4 permit.
- Costs for denitrification systems are taken from the Bay Restoration Fund and are estimated at $13,800 per system (personal communication by email with Kristin Mielcarek on 1/13/2015).
- Costs for septic upgrades to sewer are estimated from Anne Arundel (URS ESA 2016) at $50,000.

The table below is from Brown and Caldwell (2014) and shows the average cost per project per month for publicly bid restoration projects by BMP type.

Table 49: From B&C (2014) Table C-4. Estimated Average Cost per Project per Month (2017$)[a]

BMP Type	Planning Phase	Design Phase	Construction Phase	Annual O&M
Bioretention (New/Suburban)	$1,084	$2,716	$39,774	$1,522
Bioretention (Retrofit-Highly Urban)	$334	$6,502	$40,995	$1,649
Bioswale (New)	$1,084	$3,834	$31,486	$925
Bioswale (Retrofit-Highly Urban)	$760	$11,642	$74,302	$2,267
Impervious Surface Reduction	$3	$8	$399	$3
SW Retrofits (Dry ED Pond Retrofit)	$2,169	$16,615	$97,789	$2,447
Urban Forest Buffer	$209	$0	$12,179	$246
Urban Filtering Practices	$868	$4,435	$31,841	$1,298
Urban Tree Planting	$233	$0	$25,012	$275
Wet Ponds (Retrofit)	$2,169	$15,620	$88,152	$1,517
Street Sweeping[b]	$0	$0	NA	$62,189
Urban Nutrient Management	$0	$0	$0	$0
Stream Restoration	$1,303	$9,467	$44,009	$1,064
Notes:				
a. Based on Estimated Cost/Project in Table C-2 and Estimated Duration/Project in Table C-3				
b. Street sweeping capital cost assumed to be annualized over entire 20 year O&M period				
Street sweeping "construction" cost represents acquisition of street sweepers based on King-Hagan estimate of $6049/impervious acre (adjusted to 2017) x 829.5 acres, and include replacement every 10 years. King-Hagan capital cost estimated based on average between mechanical and vacuum-style sweepers.				
Street sweeping maintenance costs include both maintenance and operation of the street sweepers.				

TIMEFRAME ESTIMATES

Timeframes for the plan are based on the following by Restoration Tier:

- **Baseline:** Starts the compliance timeframe for each TMDL.
- **Completed:** Already completed between March 11, 2007 and December 30, 2014.
- **Programmed:** Scheduled to be completed between December 30, 2014 and December 30, 2019 using timeframes from the Capital Improvement Program. Includes management programs for *E. coli*.
- **Identified** and **Potential:** Timeframes begin December 30, 2019, the end date of the current MS4 permit. As part of its *Technical Memorandum No. 1: Report on Frederick County Data Review Findings* (2014), Brown and Caldwell provided timeframe estimates per project type per phase based on its experience managing public procurement contracts in the state of Maryland. These project phases are used to determine the length of project phases in the Identified and Potential Restoration Tiers. The level of implementation in each year is estimated at $4MM.

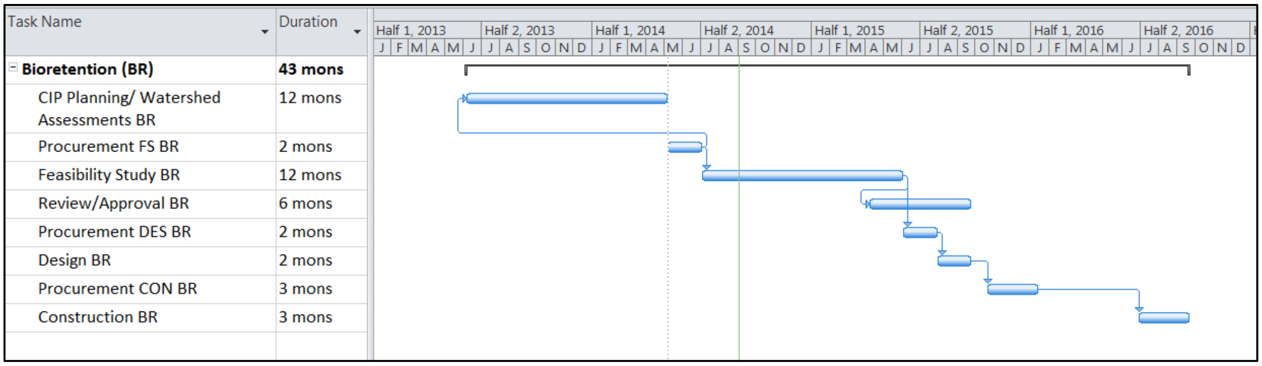


Figure 42: Example of Gantt Chart for County's Baseline Bioretention Implementation Timeframe (from Brown and Caldwell 2014)

The following table from Brown and Caldwell shows standard timeframes by project type for publicly procured restoration BMPs that was used for the Identified and Potential Scenarios.

Table 50: From B&C (2014) Table C-3. Estimated Average Duration per Project (months)

BMP Type	Planning Phase	Design Phase	Construction Phase	Annual O&M
Bioretention (New/Suburban)	33	28	12	240
Bioretention (Retrofit-Highly Urban)	33	28	12	240
Bioswale (New)	33	28	12	240
Bioswale (Retrofit-Highly Urban)	33	28	12	240
Impervious Surface Reduction	33	28	12	240
SW Retrofits (Dry ED Pond Retrofit)	33	28	12	240
Urban Forest Buffer	35	0	6	240
Urban Filtering Practices	33	28	12	240
Urban Tree Planting	35	0	6	240
Wet Ponds (Retrofit)	33	28	12	240
Street Sweeping	0	0	0	240
Urban Nutrient Management	35	0	6	240
Stream Restoration	33	28	14	240

This generic schedule translates to the following project start dates beginning Fiscal year 2021 after the end of the current permit cycle. All Identified and Potential projects were projected into this schedule as a starting point.

Table 51: From B&C (2014) Table C-5. Potential Timeframes Based on Initiation in FY16 CIP Cycle[a]

BMP Type	Potential Start	Potential Finish - Planning Phase	Potential Start - Design Phase	Potential Finish - Design Phase	Potential Start - Construction Phase	Potential Finish - Construction Phase	Potential Start - Annual O&M	Potential Finish - Annual O&M
Bioretention (New/Suburban)	Jul-20	Mar-23	Mar-23	Jul-25	Jul-25	Jun-26	Jun-26	Jun-46
Bioretention (Retrofit-Highly Urban)	Jul-20	Mar-23	Mar-23	Jul-25	Jul-25	Jun-26	Jun-26	Jun-46
Bioswale (New)	Jul-20	Mar-23	Mar-23	Jul-25	Jul-25	Jun-26	Jun-26	Jun-46
Bioswale (Retrofit-Highly Urban)	Jul-20	Mar-23	Mar-23	Jul-25	Jul-25	Jun-26	Jun-26	Jun-46
Impervious Surface Reduction	Jul-20	Mar-23	Mar-23	Jul-25	Jul-25	Jun-26	Jun-26	Jun-46
SW Retrofits (Dry ED Pond Retrofit)	Jul-20	Mar-23	Mar-23	Jul-25	Jul-25	Jun-26	Jun-26	Jun-46

Urban Forest Buffer	Jul-20	May-23	May-23	May-23	May-23	Nov-23	Nov-23	Nov-43
Urban Filtering Practices	Jul-20	Mar-23	Mar-23	Jul-25	Jul-25	Jun-26	Jun-26	Jun-46
Urban Tree Planting	Jul-20	May-23	May-23	May-23	May-23	Nov-23	Nov-23	Nov-43
Wet Ponds (Retrofit)	Jul-20	Mar-23	Mar-23	Jul-25	Jul-25	Jun-26	Jun-26	Jun-46
Street Sweeping	Jul-20	Jul-20	Jul-20	Jul-20	Jul-20	Jul-20	Jul-20	Jun-40
Urban Nutrient Management	Jul-20	May-23	May-23	May-23	May-23	Nov-23	Nov-23	Nov-43
Stream Restoration	Jul-20	Mar-23	Mar-23	Jul-25	Jul-25	Aug-26	Aug-26	Aug-46
Notes	a. Estimated schedules for any typical project identified in the future through a process that has not yet been initiated, and are based on CIP Planning start date of 7/1/2020							

Schedules for the Identified and Potential tiers are governed by a cost cap of $4MM per year to determine the final completion date of the TMDL.

COMPLETED PROJECTS, COSTS AND TIMEFRAMES

Completed projects with costs are included in Appendix 1. Estimated costs for the 160.5 completed projects counted towards this tier are $10,192,516. These BMPs were completed between March 11, 2007 and December 30, 2014.

More detail on the Completed Scenario is in the Impervious Cover Restoration Plan.

PROGRAMMED PROJECTS, COSTS AND TIMEFRAMES

Programmed costs are budgeted into the programmed five year Capital Improvement Program based on engineering cost estimates. Appendix 2 includes costs for the Programmed Scenario by project. These projects are to be completed by December 30, 2019, the end of the Permit Term.

Municipal and Financial Services Group (MFSG) was hired by the County's legal counsel, AquaLaw, PLC to "review cost data and timeframes used by the County to estimate and project the financial impact on customers to implement 20% impervious surface restoration requirements anticipated in the upcoming permit reissuance." (MFSG 2014). From an analysis of stormwater remediation fees across the country. MFSG determined that the county should escalate its total fiscal year 2015 budget 15% to include Operating and Capital per year for each year of the permit. The MS4's Programmed CIP costs generally follow this guidance.

As seen in Appendix 2, costs in FY'17 dollars for the 905.5 impervious acre equivalent projects in the five year permit programmed Capital Improvement Project Budget and other projects are $34,796,864. As seen in the table below, costs for the Programmed scenario, to include paygo and operating budget-related restoration activities, are estimated to be $48,582,365. The Programmed CIP is subject to change over time based on project development, permitting, and substitutions.

More detail on the Programmed Scenario is in the Impervious Cover Restoration Plan.

Table 52: Article 4-202.1(j)(1)(i)2: Projected annual and 5-year costs for the county or municipality to meet the impervious surface restoration plan requirements of its National Pollutant Discharge Elimination System Phase I Municipal Separate Storm Sewer System (from Financial Assurance Plan)

DESCRIPTION	PAST UP THRU FY 2014	CURRENT/ PROJECTED YEAR 1 FY 2015	PROJECTED YEAR 2 FY 2016	PROJECTED YEAR 3 FY 2017	PROJECTED YEAR 4 FY 2018	PROJECTED YEAR 5 FY 2019	PROJECTED YEAR 5 FY 2020	TOTAL COSTS
Operating Expenditures (costs)								
Street Sweeping Program	$184,764	$38,081	$39,033	$40,010	$41,009	$42,035	$43,086	$428,018
Inlet Cleaning	$368,886	$378,109	$387,561	$397,250	$407,182	$417,361	$427,795	$2,784,144
Bridge Deck Cleaning		$3,045	$3,120	$3,198	$3,278	$3,360	$3,444	$19,445
Support of Capital Projects[1]		$41,000	$618,489	$78,794	$475,648	$288,548	$1,034,308	$2,536,787
Debt Service Payment								
Other (please stipulate program expenditure)	$5,271,420	-	-	-	-	-	-	
Capital Expenditures (costs)								
General Fund (Paygo)[2]	$4,367,446	$4,241,314	$4,533,258	$4,185,741	$5,405,023	$6,945,969	$7,863,800	$37,542,551
WPR Fund (Paygo)								
Debt Service[3]					$106,000	$106,000	$256,000	$468,000
Grants & Partnerships[4]	$2,539,200	$132,480	$132,480	$132,480	$132,480	$132,480	$132,480	$3,334,080
Other (please stipulate capital expenditure)								
Subtotal operation and paygo:	$10,192,516	$4,701,549	$5,581,461	$4,704,993	$6,332,140	$7,697,273	$9,372,433	$48,582,365
Total expenditures:	**$12,731,716**	**$4,834,029**	**$5,713,941**	**$4,837,473**	**$6,570,620**	**$7,935,753**	**$9,760,913**	**$52,384,445**

[1]Support of Capital Project equals Assessments + Monitoring costs (operating impacts from Budget) for FY15, FY16 and FY17. For FY18, FY19, and FY20, it equals O&M (MEP) costs.

[2]General Fund Paygo - FY15 and 16 are Actuals from Budget. FY17 to FY20 are projected D&C from MEP.

[3]Estimate 20 year payback at 4% interest rate for FY16 and FY18 budgeted general obligation bonds. Estimated 106K payment for 20 years at 4% interest for FY16 bonds and 150K for FY18 and FY20 bonds. Payment begins the 2nd year after the bonds are issued. For FY15 FAP, these numbers are estimates and will be revised based on actuals as bonds are issued.

[4]Other Septic Denitrification from BRF Grant goes to Canaan Valley Institute

IDENTIFIED PROJECTS, COSTS AND TIMEFRAMES

Identified projects were entered into MAST from existing planning documents. These projects have engineering estimates of treated drainage areas including pervious and impervious acres. They will be completed after January 1, 2020. The studies used to develop the Identified scenario tier are listed below. Full bibliographies are in the References section.

- An Assessment of Stormwater Management Retrofit and Stream Restoration Opportunities in Ballenger Creek Watershed, Frederick County, Maryland.
- An Assessment of Stream Restoration and Stormwater Management Retrofit Opportunities in Lower Bush Creek Watershed, Frederick County, Maryland.
- Watershed Assessment of Lower Linganore Creek Frederick County, Maryland.
- An Assessment of Stormwater Management Retrofit and Stream Restoration Opportunities in Linganore Creek Watershed, Frederick County, MD.
- Final Report Watershed Assessment of Ballenger Creek Frederick County, Maryland.
- Watershed Assessment of Lower Bush Creek, Frederick County, Maryland.
- Lower Monocacy River Watershed Restoration Action Strategy (WRAS) Supplement: EPA A-I Requirements.
- Lower Monocacy River Watershed Restoration Action Strategy Frederick County, Maryland Final Report.
- Upper Monocacy River Watershed Restoration Action Strategy Frederick County, Maryland Final Report.
- Bennett Creek Watershed Assessment.
- An Assessment of Stormwater Management Retrofit and Stream Restoration Opportunities in Bennett Creek Watershed, Frederick County, Maryland.
- Chesapeake Bay TMDL Analysis for Frederick County, Maryland.
- Final Analysis of Maximum Extent Practicable for the NPDES MS4 Permit Requirements.

This scenario consists of 279 projects totaling 2,771.21 impervious acres. The cost of this tier is $217,140,365, which results in an average cost per impervious acre of $78,356. The cost without 20 years O&M calculated to net present value is $152,710,322, which amounts to $55,106 per acre.

At a cost of $4MM per year in 2017 dollars, this scenario would take 57 years. Identified projects are in Appendix 3.

Table 53: Identified Costs by BMP Type by Project Phase

BMP Type	Sum of Imperv Ac	Sum of Planning Phase	Sum of Design Phase	Sum of Construction Phase	Present Value for 20 years O&M
Bioretention/raingardens - A/B soils, no underdrain	**687.6**	**$812,844**	**$13,411,921**	**$36,242,656**	**$29,160,768**
County Phase I/II MS4 Impervious	219.3	$259,249	$4,277,607	$11,559,258	$9,300,555
County Phase I/II MS4 Pervious	464.9	$549,576	$9,067,997	$24,504,193	$19,716,024
regulated pervious developed	3.4	$4,019	$66,316	$179,205	$144,188
Bioretention/raingardens - A/B soils, underdrain	**94.0**	**$111,119**	**$1,833,455**	**$4,954,495**	**$3,986,376**
County Phase I/II MS4 Pervious	94.0	$111,119	$1,833,455	$4,954,495	$3,986,376

Bioswale	**260.7**	**$653,582**	**$8,496,572**	**$23,240,295**	**$14,182,739**
County Phase I/II MS4 Impervious	63.1	$158,324	$2,058,214	$5,629,742	$3,435,634
County Phase I/II MS4 Pervious	187.5	$470,183	$6,112,381	$16,718,925	$10,202,975
regulated pervious developed	10.0	$25,075	$325,976	$891,628	$544,130
Forest Buffers	**67.3**	**$240,936**	**$0**	**$2,409,359**	**$1,943,549**
County Phase I/II MS4 Pervious	67.3	$240,936	$0	$2,409,359	$1,943,549
Stream Restoration	**338.4**	**$1,212,023**	**$7,474,140**	**$17,372,327**	**$7,199,415**
County Phase I/II MS4 Pervious	338.4	$1,212,023	$7,474,140	$17,372,327	$7,199,415
Wet Ponds and Wetlands	**1323.3**	**$1,564,324**	**$9,559,584**	**$23,120,692**	**$7,957,195**
County Phase I/II MS4 Impervious	326.1	$385,498	$2,355,781	$5,697,663	$1,960,902
County Phase I/II MS4 Pervious	997.2	$1,178,826	$7,203,803	$17,423,029	$5,996,292
Grand Total	**2771.2**	**$4,594,827**	**$40,775,672**	**$107,339,823**	**$64,430,042**

POTENTIAL PROJECTS, COSTS AND TIMEFRAMES

The **Potential** tier consists of 1,214 projects totaling 9,651.48 impervious acres. The cost of this tier is $809,651,510, which results in an average cost per impervious acre of $83,889. The cost without 20 years O&M calculated to net present value is $570,917,447, which amounts to $59,153 per acre.

At a cost of $4MM per year in 2017 dollars, this scenario would take 202 years. Potential projects are in Appendix 4.

Table 54: Potential Costs by BMP Type by Project Phase

BMP Type	Sum of Imperv Ac	Sum of Planning Phase	Sum of Design Phase	Sum of Construction Phase	Present Value for 20 years O&M
Bioretention/raingardens - A/B soils, no underdrain	**1890**	**$2,234,191**	**$36,864,156**	**$99,616,967**	**$80,151,611**
County Phase I/II MS4 Impervious	480	$567,414	$9,362,325	$25,299,547	$20,355,965
County Phase I/II MS4 Pervious	1410	$1,666,778	$27,501,830	$74,317,420	$59,795,646
Bioswale	**861**	**$2,158,966**	**$28,066,557**	**$76,769,209**	**$46,849,561**
County Phase I/II MS4 Impervious	343	$860,076	$11,180,986	$30,582,855	$18,663,646
County Phase I/II MS4 Pervious	518	$1,298,890	$16,885,571	$46,186,353	$28,185,915
Forest Buffers	**1404.48**	**$5,031,068**	**$0**	**$50,310,677**	**$40,583,946**
County Phase I/II MS4 Pervious	1404.48	$5,031,068	$0	$50,310,677	$40,583,946
Stream Restoration	**2496**	**$8,941,064**	**$55,136,559**	**$128,155,245**	**$53,109,918**
County Phase I/II MS4 Impervious	1776	$6,361,911	$39,231,782	$91,187,386	$37,789,749

County Phase I/II MS4 Pervious	720	$2,579,153	$15,904,777	$36,967,859	$15,320,169
Wet Ponds and Wetlands	**3000**	**$3,546,335**	**$21,671,655**	**$52,414,799**	**$18,039,026**
County Phase I/II MS4 Impervious	1000	$1,182,112	$7,223,885	$17,471,600	$6,013,009
County Phase I/II MS4 Pervious	2000	$2,364,224	$14,447,770	$34,943,199	$12,026,017
Grand Total	**9651.5**	**$21,911,624**	**$141,738,927**	**$407,266,897**	**$238,734,062**

CONCLUSION

This Frederick County Stormwater Restoration Plan satisfies the requirements of PART IV.E.2.a and b of the NPDES MS4 permit 11-DP-3321 MD0068357 dated December 30, 2014 for the Impervious Cover Restoration Plan and Total Maximum Daily Load (TMDL) Restoration Plans. The Plan will take a cumulative 268.81 years to address TMDL requirements (259.5 years from today's date), will restore an estimated 13,435.69 impervious acres and will cost a cumulative amount of $1,085,566,756.

Table 55: Timeframes, Cumulative Acres and Costs by Tier for Stormwater Restoration Plan

Scenario	Begin Date	Complete Date	Cum Duration Years	Cum Acres	Cost
Complete	3/11/2007	12/30/2014	7.81	106.5	$10,192,516
Programmed	12/30/2014	12/30/2019	12.81	1013	$48,582,365
Identified	12/30/2019	12/16/2073	66.81	3784.21	$217,140,365
Potential	12/16/2073	10/29/2275	268.81	13435.69	$809,651,510
Total					**$1,085,566,756**

These projects will address the Chesapeake Bay TMDL for nitrogen, which governs the costs and schedules for all other Restoration Plans in this document. The following reductions are achieved by subwatershed under the Chesapeake Bay TMDL Restoration Plan for Nitrogen:

Table 56: Edge of Stream and Delivered loads in Chesapeake Bay Nitrogen TMDL Restoration Plan

Segment	Acres	N Load EOS	N Load DEL	P Load EOS	P Load DEL	S Load EOS	S Load DEL
Catoctin Creek	7653.64	167072	54504.11	4975.96	2334.39	3173334.28	2055982.09
Double Pipe Creek	1427.22	29717.89	7387.7	1008.94	473.33	573474.29	371550.14
Lower Monocacy River	31835.76	555804.52	313074.87	10562.94	4955.43	2632748.7	1705740.28
Potomac River FR Cnty	3656.79	76127.69	56101.74	3022.12	1417.77	1329669.91	861484.23
Potomac River MO Cnty	53	1144.09	886.3	51.1	23.97	19422.4	12583.64
Upper Monocacy River	7532.97	153151.39	64046.82	3849.06	1805.72	1534041.09	993894.94
Grand Total	52159.38	983017.58	496001.54	23470.12	11010.61	9262690.67	6001235.32

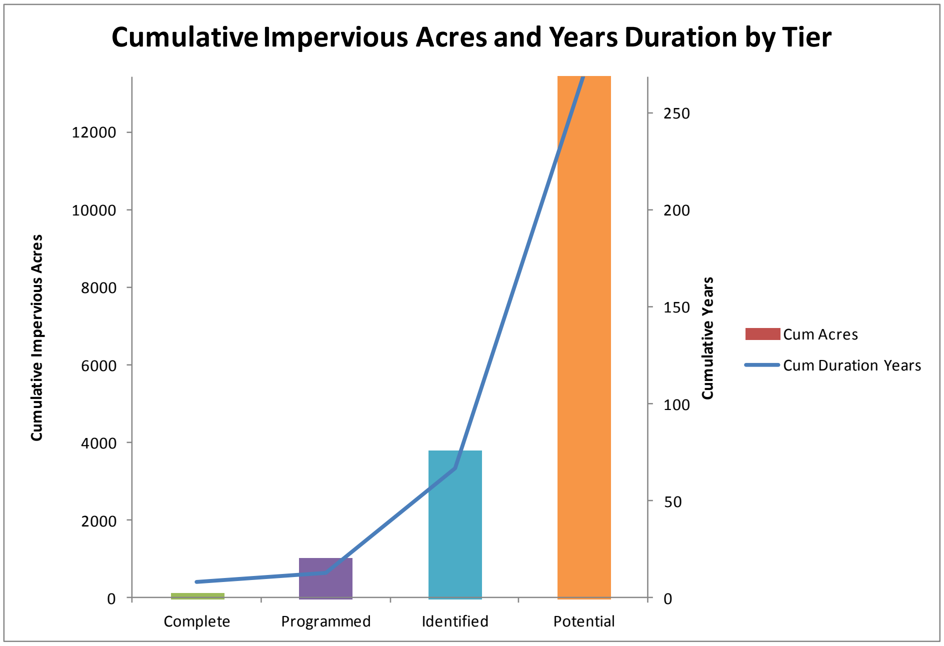


Figure 43: Cumulative Impervious Acres and Years Duration by Tier for Stormwater Restoration Plan

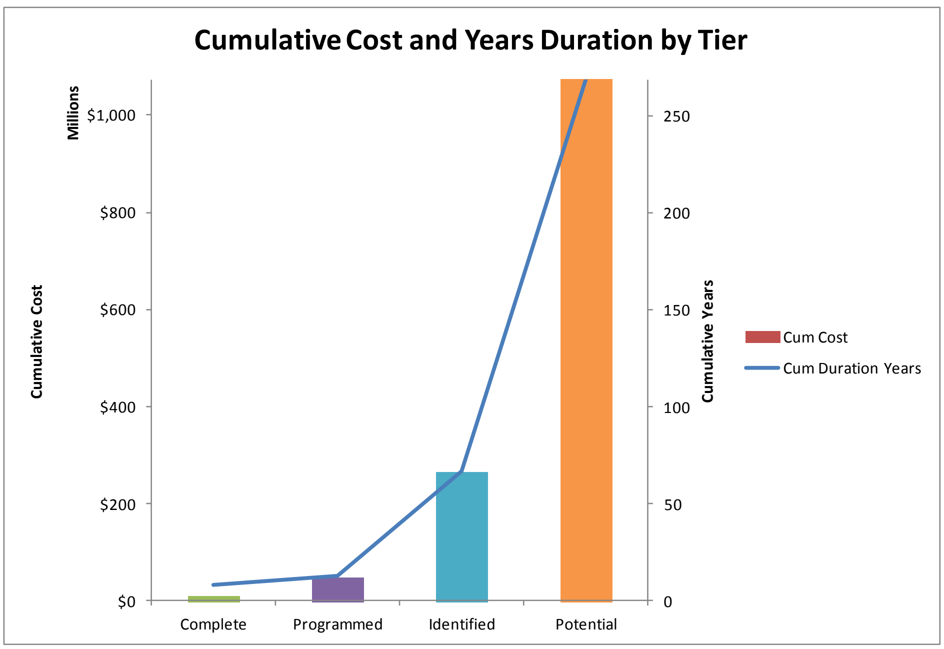


Figure 44: Cumulative Costs and Years Duration by Tier for Stormwater Restoration Plan

A previous cost estimate for the Frederick County MS4 SW-WLA for the Chesapeake Bay TMDL was in the TMDL Local Area Plan that Frederick County Government submitted to meet requirements for the Phase II Watershed Implementation Plan. That document estimated the cost at $652,497,347; however, several significant differences exist between that plan and this one. The WIP included several thousand acres of urban nutrient management. That practice, the cheapest of all accepted practices, was allowed in a previous version of the Stormwater Accounting Guidance but is not in the 2014 version because of the statewide fertilizer law. The WIP also included several thousand acres of infiltration practices, which Brown and Caldwell (2014) determined were not suitable to most

Frederick County soils; this also removed a very cost effective practice. The Brown and Caldwell cost estimates are less expensive for forest than the King and Hagen estimates used for the WIP, but other practices like bioswales are more expensive due to Frederick County soils. The acre basis is also different; this Stormwater Restoration Plan is based on very specific instructions from MDE for calibration and disaggregation, where the Local Area Plan assumed a general land use percent of the total.

This document relies on currently accepted practices to meet the pollutant and impervious cover restoration requirements that are required by the MS4 permit and the Stormwater Accounting Guidance.; however, it is clear in the case of Frederick County that alternatives must be considered in the future in order to address the TMDL. The question should be asked: what is the most cost effective way to reduce the pollutants in the local and Bay TMDLs? The answer to that will likely include a number of key concepts:

1. Reduction of atmospheric deposition of nitrogen: the Chesapeake Bay TMDL 2010 baselines from EPA included atmospheric deposition reductions from nitrogen due to portions of the Clean Air Act that were implemented. Future actions, such as the low sulfur fuels standard, were not included. Future versions of EPA allocations will likely show additional reductions from expanded implementation of the CAA and other air rules. Maryland applied reductions from its own Clean Cars Act and Healthy Air Act to open water, as no BMPs currently exist for this land use; however if the reductions occur across the land they should be more evenly distributed. EPA also allowed the state to count 50% of the reductions from its actions in early versions of the state's WIP; a more sophisticated modeling approach should be used that reflects actual deposition. Other states also have engaged in atmospheric pollutant reductions, and these reductions will also benefit Maryland. Since the Chesapeake Bay TMDL for Nitrogen governs Frederick County's schedules, reduction of nitrogen has a direct bearing on the cost and timeframes of Frederick County's plan. Consideration should also be given for BMPs that the County implements to reduce atmospheric pollution, such as the conversion of its bus fleet to all-electric.
2. The Maryland Department of the Environment is developing a water quality trading program that will be developed in the latter half of 2016. This could allow for other kinds of practices like agricultural cover crops to substitute for urban stormwater practices. Urban stormwater practices are the most expensive practices for Bay restoration. The cost to reduce a pound of N per year in this plan is close to $600.
3. Large scale (baywide or statewide) education and management programs for pet waste and urban fertilization could provide a cost-effective way of reducing pollution that is not clearly addressed in the Stormwater Accounting Guidance.
4. Public procurement is designed to protect the public's interests but also has a great deal of overhead; to reduce the cost per acre below the $79,932 estimated for this plan, multiple options should be considered:
    a. Grant issuances: Several jurisdictions have issued RFPs asking for bids on the most cost effective pollutant and impervious area reductions. Others have worked with the Chesapeake Bay Trust to issue grant opportunities that the Trust manages for a minimum amount of overhead. In both options, the public procurement is reduced and private and non-profit entities can compete on a price basis.
    b. Public-Private Partnerships: A longer-term relationship model for Public-Private Partnerships (P3s) exists. Essentially the private partner implements the restoration and maintenance efforts and is responsible for specific performance metrics like cost per acre restored or pound of pollutant reduced. The partner can provide long-term financing. The County pays the private partner through bonds or another revenue source.

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APPENDIX 1: COMPLETED PROJECTS, COSTS AND IMPERVIOUS ACRES TREATED

Table 57: Article 4-202.1(j)(1)(i)5: Specific actions and expenditures that the county or municipality implemented in the previous fiscal years to meet its impervious surface restoration plan requirements under its National Pollutant Discharge Elimination System Phase I Municipal Separate Storm Sewer System Permit (from Financial Assurance Plan)

REST BMP ID	REST BMP TYPE	BMP CLASS	NUM BMP	IMP ACRES	BUILT DATE	IMPL COST
Operation Programs						
Street Sweeping	MSS	A	1	0	12/29/2014	$184,764
Inlet Cleaning	CBC	A	1	0	12/29/2014	$368,886
Subtotal Op Complete To Date*			**1**	**0**		**$553,650**
Capital Projects						
Urbana High School Retrofit	BIO	ST	1	2.83	10/1/2007	$249,069
Ballenger Creek Stream Rest	STRE	A	1	6.05	5/1/2007	$406,986
Pinecliff Park Stream Rest	STRE	A	1	10	11/12/2010	$427,658
Public Safety Training Facility	WP	A	1	15	1/1/2010	$989,970
Citizens Care and Rehab	WP	ST	1	25.16	1/1/2012	$1,660,509
Englandtowne Stream Rest	STRE	A	1	7.3	12/1/2014	$633,254
Subtotal Capital Complete To Date			**6**	**66.34**		**$4,367,446**
Other						
Support of Capital Projects			0	0	Through 2014	$926,566
Catoctin Mountain Park	PP	A	1	0.1	11/1/2012	$23,958.00
Septic Denitrification (BRF)	SEPD	A	184	47.84	12/29/2014	$2,539,200.00
Septic Connections to WWTP	SEPC	A	7	2.73	12/29/2014	$350,000.00
Septic Pumping	SEPP	A	0	0	12/29/2014	NA
Urbana Community Park	ESDSW	RR	1	0.26	12/1/2013	$11,440.00
Cooperative Extension Building	ESDRG	RR	1	0.25	12/1/2013	$750
Orchard Grove Elementary School	FPU	A	1	0.32	5/15/2013	$10,560.00
Spring Ridge Elementary School	FPU	A	1	1.05	4/1/2013	$34,650.00
Crestwood Middle School	FPU	A	1	0.79	4/1/2013	$26,070.00
Monocacy National Battlefield	FPU	A	1	4.95	11/26/2012	$163,350.00
Parkway Elementary School	FPU	A	1	0	9/1/2012	$0.00
Pinecliff Park	FPU	A	1	0.79	8/1/2012	$26,070.00
Woodsboro Elementary School	FPU	A	1	0	5/15/2012	$0.00
Woodsboro Community Park	FPU	A	1	0	3/30/2012	$0.00
Windsor Knolls Middle School	FPU	A	2	4.56	12/1/2011	$150,480.00
Urbana Elementary School	FPU	A	1	0.13	8/30/2011	$4,290.00
Rivermist Park	FPU	A	1	0	7/1/2011	$0.00

Old National Pike Park	FPU	A	1	1.83	4/1/2011	$60,390.00
West Frederick Middle	FPU	A	1	0	9/1/2010	$0.00
Worthington Manor Golf Course	FPU	A	1	0	7/1/2010	$0.00
GTJ Middle School	FPU	A	1	0	5/1/2010	$0.00
Windsor Knolls Elementary	FPU	A	1	4.7	5/1/2010	$155,100.00
Cunningham Fall State Park	FPU	A	1	0	4/29/2010	$0.00
Brunswick High School	FPU	A	1	0.37	4/6/2010	$12,210.00
Catoctin Mountain Park	FPU	A	1	2.15	4/1/2010	$70,950.00
Catoctin Mountain Park	GMB	ESD	1	0	4/1/2010	$0.00
Emmitsburg Elementary School	FPU	A	1	0	5/1/2009	$0.00
Urbana Community Park	FPU	A	1	0.9	4/27/2009	$29,700.00
Oakdale Elementary School	FPU	A	1	0	4/22/2009	$0.00
Middletown High School	FPU	A	1	0.16	4/7/2009	$5,280.00
Kemptown Elementary School	FPU	A	1	0	1/1/2009	$0.00
Mt. Airy Windy Ridge Park	FPU	A	1	0	10/31/2008	$0.00
Urbana Middle School	FPU	A	1	0.46	5/31/2008	$15,180.00
Liberty Village	FPU	A	1	0.7	5/15/2008	$23,100.00
Mt. Airy Village Gate Park	FPU	A	1	1	4/12/2008	$33,000.00
Valley Elementary School	FPU	A	1	0.79	4/1/2008	$26,070.00
Urbana Elementary School	ESDSW	RR	1	0.004	12/1/2007	$176
Tuscarora Elementary School	FPU	A	1	0	11/1/2007	$0.00
Urbana High School	FPU	A	1	0	11/1/2007	$0.00
Mountain Village HOA	FPU	A	1	1.22	11/1/2007	$40,260.00
Ballenger Creek Elementary School	FPU	A	1	0.58	11/1/2007	$19,140.00
Walkersville High and Elem	FPU	A	1	0	10/22/2007	$0.00
Holly Hills Country Club	FPU	A	1	5.79	10/10/2007	$191,070.00
Holly Hills HOA	FPU	A	1	0.44	10/10/2007	$14,520.00
Deer Crossing Elementary School	FPU	A	1	1.09	5/20/2007	$35,970.00
Cloverhill	FPU	A	1	0.51	5/1/2007	$16,830.00
Utica Park	FPU	A	1	0.29	4/26/2007	$9,570.00
New Forest Society Nursery	FPU	A	1	0	4/16/2007	$0.00
Fred Archibald Santuary	FPU	A	1	2.58	4/1/2007	$85,140.00
Libertytown Park	FPU	A	1	1.56	4/1/2007	$51,480.00
Mt. Saint Mary's Run	FPU	A	1	0	4/1/2007	$0.00
Walkersville Community Park	FPU	A	1	0	4/1/2007	$0.00
Wolfsville Elementary	FPU	A	1	0.41	4/1/2007	$13,530.00
Mt. Airy East West Park	FPU	A	1	1.43	3/31/2007	$47,190.00
Monocacy Elementary School	FPU	A	1	0.04	1/1/2007	$1,320.00
St. Peter the Apostle Church	FPU	A	1	0.2	10/31/2006	$6,600.00

New Market Middle School	FPU	A	1	1.22	7/1/2006	$40,260.00
Subtotal Other Complete To Date			**246**	**94**		**$5,271,420**
Total Complete to Date			**253**	**160.5**		**$10,192,516**

APPENDIX 2: PROGRAMMED PROJECTS, COSTS AND IMPERVIOUS ACRES TREATED

Table 58: Modified from Article 4-202.1(j)(1)(i)1: Actions that will be required of the county or municipality to meet the requirements of its National Pollutant Discharge Elimination System Phase I Municipal Separate Storm Sewer System Permit (from Financial Assurance Plan)

REST BMP TYPE*	BMP CLASS	IMP ACRES	IMPL COST	IMPL STATUS**	PROJECTED IMPL YR
Operation Programs					
VSS	A	0	$41,126	COMPLETE	2015
VSS	A	0	$42,153	UNDER CONSTRUCTION	2016
VSS	A	0	$43,208	PLANNING	2017
VSS	A	0	$44,287	PLANNING	2018
VSS	A	0	$45,395	PLANNING	2019
VSS	A	0	$46,530	PLANNING	2020
SDV	A	0	$378,109	PLANNING	2015
SDV	A	0	$387,561	PLANNING	2016
SDV	A	0	$397,250	PLANNING	2017
SDV	A	0	$407,182	PLANNING	2018
SDV	A	0	$417,361	PLANNING	2019
SDV	A	0	$427,795	PLANNING	2020
Average Operations Permit Term and Projected Years (FY2015-FY2020)***		0.0	$2,677,957		
Capital Projects					
WP	ST	13.7	$681,300	UNDER CONSTRUCTION	2017
EDSW	ST	3.77	$305,252	PLANNING	2017
IB	RR	4.61	$344,869	PLANNING	2017
WP	ST	4.46	$350,102	PLANNING	2017
EDSW	ST	72.45	$6,774,075	PLANNING	2017
PPKTSF	ST	1.38	$103,500	PLANNING	2017
EDSW	ST	19.47	$1,752,250	PLANNING	2017
IMPF	A	1.3	$583,053	PLANNING	2017
FPU	A	4.18	$137,940	PLANNING	2017
FPU	A	7.22	$238,260	PLANNING	2018
FPU	A	11.6	$382,553	PLANNING	2018
STRE	A	18	$1,660,351	PLANNING	2018
FPU	A	2.39	$0	PLANNING	2018
WSHW	A	12.21	$0	PLANNING	2018
BR	RR	10.56	$559,159	PLANNING	2018
EDSW	ST	103.5	$1,287,667	PLANNING	2018

EDSW	ST	8	$870,695	PLANNING	2019
STRE	A	40	$4,428,179	PLANNING	2019
STRE	A	9.4	$1,598,593	PLANNING	2019
FPU	A	1.06	$0	PLANNING	2019
FPU	A	43.73	$1,443,250	PLANNING	2019
FPU	A	41.8	$1,379,400	PLANNING	2019
STRE	A	31.15	$1,598,593	PLANNING	2020
FPU	A	3.11	$0	PLANNING	2020
FPU	A	18.7	$615,299	PLANNING	2020
FPU	A	19	$627,000	PLANNING	2020
FPU	A	32.3	$1,065,900	PLANNING	2020
Subtotal Capital Permit Term and Projected Years (FY2015-FY2020)		539	$28,787,240		
Other					
Proposed trading program	A	255.8	$0	PLANNING	2020
SEPD	A	9.6	$132,480	COMPLETE	2015
SEPD	A	9.6	$132,480	UNDER CONSTRUCTION	2016
SEPD	A	9.6	$132,480	PLANNING	2017
SEPD	A	9.6	$132,480	PLANNING	2018
SEPD	A	9.6	$132,480	PLANNING	2019
SEPD	A	9.6	$132,480	PLANNING	2020
Operating Support of CIP		0	$41,000	COMPLETE	2015
Operating Support of CIP		0	$618,489	UNDER CONSTRUCTION	2016
Operating Support of CIP		0	$78,794	PLANNING	2017
Operating Support of CIP		0	$475,648	PLANNING	2018
Operating Support of CIP		0	$288,548	PLANNING	2019
Operating Support of CIP		0	$1,034,308	PLANNING	2020
Subtotal Other Permit Term and Projected Years (FY2015-FY2020)		313	$3,331,667		
Total Permit Term and Projected Years (FY2015-FY2020)		**852.5**	**$34,796,864**		

APPENDIX 3: IDENTIFIED PROJECTS, COSTS AND IMPERVIOUS ACRES TREATED

See Appendix 3 document.

APPENDIX 4: POTENTIAL PROJECTS, COSTS AND IMPERVIOUS ACRES TREATED

See Appendix 4 document

APPENDIX 5: LOWER MONOCACY SEDIMENT SCENARIOS

COMPLETED RESTORATION PROJECTS

The table below shows all projects in the Lower Monocacy that are Completed for sediment.

Table 59: Summary of all Completed Sediment BMPs Implemented for the Lower Monocacy

Practice information	Sum of Total Credited
Bioretention/raing ardens - A/B soils, no underdrain	5.48
acres treated	5.48
Efficiency	5.48
regulated impervious developed	0.01
regulated pervious developed	5.47
Bioretention/rain gardens - A/B soils, underdrain	6.71
acres treated	6.71
Efficiency	6.71
regulated impervious developed	0
regulated pervious developed	6.71
Bioswale	0.26
acres treated	0.26
Efficiency	0.26
regulated impervious developed	0.26
regulated pervious developed	0
Forest Buffers	182.78
acres in buffers	182.78
Efficiency	91.39
regulated impervious developed	16.77
regulated pervious developed	74.62
Landuse Change	91.39
regulated pervious developed	91.39

Grass Buffers	14.26
acres in buffers	14.26
Landuse Change	14.26
regulated pervious developed	14.26
Stream Restoration	3005
feet	3005
Pound Reduction	3005
regulated pervious developed	3005
Tree Planting	18.81
acres	18.81
Landuse Change	18.81
regulated pervious developed	18.81
Wet Ponds and Wetlands	28.7
acres treated	28.7
Efficiency	28.7
regulated impervious developed	25.16
regulated pervious developed	3.54

COMPLETED LOAD REDUCTIONS

Table 60: Sum of Completed Edge of Stream Sediment Load Reductions for the Lower Monocacy

Land Use	Total
regulated impervious developed	32132
regulated pervious developed	171196
Grand Total	**203328**

PROGRAMMED RESTORATION PROJECTS

Table 61: Summary of all Programmed Sediment BMPs for the Lower Monocacy

BMPs	Sum of Total Credited
Bioretention/rain gardens - A/B soils, no underdrain	**5.47**
acres treated	**5.47**
Efficiency	5.47
regulated impervious developed	0.25
regulated pervious developed	5.22
Bioretention/rain gardens - A/B soils, underdrain	**37.05**
acres treated	**37.05**
Efficiency	37.05
regulated impervious developed	4.65
regulated pervious developed	32.4
Bioretention/rain gardens - C/D soils, underdrain	**13.61**
acres treated	**13.61**
Efficiency	13.61
regulated impervious developed	5.13
regulated pervious developed	8.48
Bioswale	**19.6**
acres treated	**19.6**
Efficiency	19.6
regulated impervious developed	4.68
regulated pervious developed	14.92
Dry Detention Ponds and Hydrodynamic Structures	**697.68**
acres treated	**697.68**
Efficiency	697.68
regulated impervious developed	218.99
regulated pervious developed	478.69
Dry Extended Detention Ponds	**2255.54**
acres treated	**2255.54**
Efficiency	2255.54

regulated impervious developed	792.14
regulated pervious developed	1463.4
Filtering Practices	**18.73**
acres treated	**18.73**
Efficiency	18.73
regulated impervious developed	1.7
regulated pervious developed	17.03
Forest Buffers	**397.54**
acres in buffers	**397.54**
Efficiency	198.77
regulated impervious developed	36.79
regulated pervious developed	161.98
Landuse Change	198.77
regulated pervious developed	198.77
Grass Buffers	**14.26**
acres in buffers	**14.26**
Landuse Change	14.26
regulated pervious developed	14.26
Infiltration Practices w/ Sand, Veg. - A/B soils, no underdrain	**10.09**
acres treated	**10.09**
Efficiency	10.09
regulated impervious developed	4.71
regulated pervious developed	5.38
Infiltration Practices w/o Sand, Veg. - A/B soils, no underdrain	**141.54**
acres treated	**141.54**
Efficiency	141.54
regulated impervious developed	39.41
regulated pervious developed	102.13
Stream Restoration	**4110**

feet	**4110**
Pound Reduction	4110
regulated pervious developed	4110
Tree Planting	**18.81**
acres	**18.81**
Landuse Change	18.81
regulated pervious developed	18.81
Vegetated Open Channels - A/B soils, no underdrain	**9.93**
acres treated	**9.93**
Efficiency	9.93
regulated impervious developed	1.92
regulated pervious developed	8.01
Vegetated Open Channels - C/D soils, no underdrain	**1.03**
acres treated	**1.03**
Efficiency	1.03
regulated impervious developed	0.16
regulated pervious developed	0.87
Wet Ponds and Wetlands	**2744.1**
acres treated	**2744.1**
Efficiency	2744.1
regulated impervious developed	577.94
regulated pervious developed	2166.16

PROGRAMMED LOAD REDUCTIONS

Table 62: Sum of Programmed Edge of Stream Sediment Load Reductions for the Lower Monocacy

Sum of SLoadEOS	
Row Labels	**Total**
regulated impervious developed	125864
regulated pervious developed	127169

Grand Total	**253033**

IDENTIFIED RESTORATION PROJECTS

Table 63: Summary of all Identified Sediment BMPs for the Lower Monocacy

Row Labels	Sum of Total Credited
Bioretention/rain gardens - A/B soils, no underdrain	**846.13**
acres treated	**846.13**
Efficiency	846.13
regulated impervious developed	254.31
regulated pervious developed	591.82
Bioretention/rain gardens - A/B soils, underdrain	**99**
acres treated	**99**
Efficiency	99
regulated impervious developed	2.75
regulated pervious developed	96.25
Bioswale	**337.92**
acres treated	**337.92**
Efficiency	337.92
regulated impervious developed	98.13
regulated pervious developed	239.79
Forest Buffers	**378**
acres in buffers	**378**
Efficiency	189
regulated impervious developed	35.39
regulated pervious developed	153.61
Landuse Change	189
regulated pervious developed	189
Stream Restoration	**32835**
feet	**32835**

Pound Reduction	32835
regulated pervious developed	32835
Wet Ponds and Wetlands	**926**
acres treated	**926**
Efficiency	926
regulated impervious developed	258.66
regulated pervious developed	667.34

IDENTIFIED LOAD REDUCTIONS

Table 64: Sum of Identified Edge of Stream Sediment Load Reductions for the Lower Monocacy

Sum of SLoadEOS	
Row Labels	**Total**
regulated impervious developed	689054
regulated pervious developed	1798237
Grand Total	**2487291**

POTENTIAL PROJECTS

Table 65: Summary of all Potential Sediment BMPs for the Lower Monocacy

Row Labels	Sum of Total Credited
Bioswale	320
acres treated	320
Efficiency	320
regulated impervious developed	112
regulated pervious developed	208
Forest Buffers	2940
acres in buffers	2940
Efficiency	1470
regulated impervious developed	295.23
regulated pervious developed	1174.77

Landuse Change	1470
regulated pervious developed	1470
Stream Restoration	77999.99
feet	77999.99
Pound Reduction	77999.99
regulated impervious developed	24000
regulated pervious developed	53999.99

POTENTIAL LOAD REDUCTIONS

Table 66: Sum of Potential Edge of Stream Sediment Load Reductions for the Lower Monocacy

Sum of SLoadEOS	
Row Labels	Total
regulated impervious developed	1351873
regulated pervious developed	2142998.7
Grand Total	**3494871.7**

APPENDIX 6: LOWER MONOCACY PHOSPHORUS SCENARIOS

COMPLETED RESTORATION PROJECTS

The table below shows all projects in the Lower Monocacy that are Completed for phosphorus.

Table 67: Summary of all Completed Sediment BMPs Implemented for the Lower Monocacy

Practice information	Sum of Total Credited
Bioretention/rain gardens - A/B soils, no underdrain	5.48
acres treated	5.48
Efficiency	5.48
regulated impervious developed	0.01
regulated pervious developed	5.47
Bioretention/rain gardens - A/B soils, underdrain	6.71
acres treated	6.71
Efficiency	6.71
regulated impervious developed	0
regulated pervious developed	6.71
Bioswale	0.26
acres treated	0.26
Efficiency	0.26
regulated impervious developed	0.26
regulated pervious developed	0
Forest Buffers	182.78
acres in buffers	182.78
Efficiency	91.39
regulated impervious developed	16.77
regulated pervious developed	74.62
Landuse Change	91.39
regulated pervious developed	91.39

Grass Buffers	14.26
acres in buffers	14.26
Landuse Change	14.26
regulated pervious developed	14.26
Stream Restoration	3005
feet	3005
Pound Reduction	3005
regulated pervious developed	3005
Tree Planting	18.81
acres	18.81
Landuse Change	18.81
regulated pervious developed	18.81
Wet Ponds and Wetlands	28.7
acres treated	28.7
Efficiency	28.7
regulated impervious developed	25.16
regulated pervious developed	3.54

COMPLETED LOAD REDUCTIONS

Table 68: Sum of Completed Edge of Stream Phosphorus Load Reductions for the Lower Monocacy

Sum of PLoadEOS	
Row Labels	Total
regulated impervious developed	22.1
regulated pervious developed	166.9
Grand Total	**189**

PROGRAMMED RESTORATION PROJECTS

Table 69: Summary of all Programmed Phosphorus BMPs for the Lower Monocacy

Row Labels	Sum of Total Credited
Bioretention/rain gardens - A/B soils, underdrain	**0.01**
acres treated	**0.01**
Efficiency	0.01
regulated impervious developed	0.01
regulated pervious developed	0
Bioswale	**16.4**
acres treated	**16.4**
Efficiency	16.4
regulated impervious developed	3.5
regulated pervious developed	12.9
Forest Buffers	**220**
acres in buffers	**220**
Efficiency	110
regulated impervious developed	20.34
regulated pervious developed	89.66
Landuse Change	110
regulated pervious developed	110
Infiltration Practices w/ Sand, Veg. - A/B soils, no underdrain	**8.7**
acres treated	**8.7**
Efficiency	8.7
regulated impervious developed	4.61
regulated pervious developed	4.09
Stream Restoration	**1105**
feet	**1105**
Pound Reduction	1105
regulated pervious developed	1105
Wet Ponds and Wetlands	**416.79**

acres treated	**416.79**
Efficiency	416.79
regulated impervious developed	119.03
regulated pervious developed	297.76

PROGRAMMED LOAD REDUCTIONS

Table 70: Sum of Programmed Edge of Stream Phosphorus Load Reductions for the Lower Monocacy

Sum of PLoadEOS	
Row Labels	**Total**
regulated impervious developed	173.5
regulated pervious developed	167.5
Grand Total	**341**

IDENTIFIED RESTORATION PROJECTS

Table 71: Summary of all Identified Phosphorus BMPs for the Lower Monocacy

Row Labels	**Sum of Total Credited**
Bioretention/rain gardens - A/B soils, no underdrain	**846.13**
acres treated	**846.13**
Efficiency	846.13
regulated impervious developed	254.31
regulated pervious developed	591.82
Bioretention/rain gardens - A/B soils, underdrain	**99**
acres treated	**99**
Efficiency	99
regulated impervious developed	2.75
regulated pervious developed	96.25
Bioswale	**337.92**
acres treated	**337.92**
Efficiency	337.92

regulated impervious developed	98.13
regulated pervious developed	239.79
Forest Buffers	**378**
acres in buffers	**378**
Efficiency	189
regulated impervious developed	35.39
regulated pervious developed	153.61
Landuse Change	189
regulated pervious developed	189
Stream Restoration	**32835**
feet	**32835**
Pound Reduction	32835
regulated pervious developed	32835
Wet Ponds and Wetlands	**926**
acres treated	**926**
Efficiency	926
regulated impervious developed	258.66
regulated pervious developed	667.34

IDENTIFIED LOAD REDUCTIONS

Table 72: Sum of Identified Edge of Stream Phosphorus Load Reductions for the Lower Monocacy

Row Labels	Sum of PLoadEOS
regulated impervious developed	1032.8
regulated pervious developed	2975.5
Grand Total	**4008.3**

POTENTIAL PROJECTS

Table 73: Summary of all Potential Phosphorus BMPs for the Lower Monocacy

Row Labels	Sum of Total Credited
Bioswale	320
acres treated	320
Efficiency	320
regulated impervious developed	112
regulated pervious developed	208
Forest Buffers	2940
acres in buffers	2940
Efficiency	1470
regulated impervious developed	295.23
regulated pervious developed	1174.77
Landuse Change	1470
regulated pervious developed	1470
Stream Restoration	77999.99
feet	77999.99
Pound Reduction	77999.99
regulated impervious developed	24000
regulated pervious developed	53999.99

POTENTIAL LOAD REDUCTIONS

Table 74: Sum of Potential Edge of Stream Phosphorus Load Reductions for the Lower Monocacy

Sum of PLoadEOS	
Row Labels	Total
regulated impervious developed	1171.4
regulated pervious developed	3365.7
Grand Total	**4537.1**

COMPLETED RESTORATION PROJECTS

The table below shows all projects in the Upper Monocacy that are Completed for sediment.

Table 75: Summary of all Completed Sediment BMPs Implemented for the Upper Monocacy

Row Labels	Sum of Total Credited
Forest Buffers	5.24
acres in buffers	5.24
Efficiency	2.62
regulated impervious developed	0.32
regulated pervious developed	2.3
Landuse Change	2.62
regulated pervious developed	2.62

COMPLETED LOAD REDUCTIONS

Table 76: Sum of Completed Edge of Stream Sediment Load Reductions for the Upper Monocacy

Row Labels	Sum of SLoadEOS
regulated impervious developed	226
regulated pervious developed	880
Grand Total	**1106**

PROGRAMMED RESTORATION PROJECTS

Table 77: Summary of all Programmed Sediment BMPs for the Upper Monocacy

Row Labels	Sum of Total Credited
Forest Buffers	**170**

acres in buffers	**170**
Efficiency	85
regulated impervious developed	10.64
regulated pervious developed	74.36
Landuse Change	85
regulated pervious developed	85

PROGRAMMED LOAD REDUCTIONS

Table 78: Sum of Programmed Edge of Stream Sediment Load Reductions for the Upper Monocacy

Row Labels	Total
regulated impervious developed	7429
regulated pervious developed	28529
Grand Total	**35958**

IDENTIFIED RESTORATION PROJECTS

Table 79: Summary of all Identified Sediment BMPs for the Upper Monocacy

Row Labels	Sum of Total Credited
Bioswale	**30.44**
acres treated	**30.44**
Efficiency	30.44
regulated impervious developed	8.95
regulated pervious developed	21.49
Wet Ponds and Wetlands	**90.11**
acres treated	**90.11**
Efficiency	90.11
regulated impervious developed	16.83
regulated pervious developed	73.28

IDENTIFIED LOAD REDUCTIONS

Table 80: Sum of Identified Edge of Stream Sediment Load Reductions for the Upper Monocacy

Row Labels	Total
regulated impervious developed	24933
regulated pervious developed	13683
Grand Total	**38616**

POTENTIAL PROJECTS

Table 81: Summary of all Potential Sediment BMPs for the Upper Monocacy

Row Labels	Sum of Total Credited
Bioswale	80
acres treated	80
Efficiency	80
regulated impervious developed	28
regulated pervious developed	52
Forest Buffers	756
acres in buffers	756
Efficiency	378
regulated impervious developed	51.12
regulated pervious developed	326.88
Landuse Change	378
regulated pervious developed	378
Stream Restoration	20400
feet	20400
Pound Reduction	20400
regulated impervious developed	2400
regulated pervious developed	18000

POTENTIAL LOAD REDUCTIONS

Table 82: Sum of Potential Edge of Stream Sediment Load Reductions for the Upper Monocacy

Row Labels	Sum of SLoadEOS
regulated impervious developed	173911.1
regulated pervious developed	926940.8
Grand Total	**1100851.9**

COMPLETED RESTORATION PROJECTS

The table below shows all projects in the Upper Monocacy that are Completed for phosphorus.

Table 83: Summary of all Completed Sediment BMPs Implemented for the Upper Monocacy

Row Labels	Sum of Total Credited
Forest Buffers	5.24
acres in buffers	5.24
Efficiency	2.62
regulated impervious developed	0.31
regulated pervious developed	2.31
Landuse Change	2.62
regulated pervious developed	2.62

COMPLETED LOAD REDUCTIONS

Table 84: Sum of Completed Edge of Stream Phosphorus Load Reductions for the Upper Monocacy

Row Labels	Sum of PLoadEOS
regulated impervious developed	0.4
regulated pervious developed	2.3
Grand Total	**2.7**

PROGRAMMED RESTORATION PROJECTS

Table 85: Summary of all Programmed Phosphorus BMPs Implemented for the Upper Monocacy

Row Labels	Sum of Total Credited
Forest Buffers	**170**
acres in buffers	**170**

Efficiency	85
regulated impervious developed	10.04
regulated pervious developed	74.96
Landuse Change	85
regulated pervious developed	85

PROGRAMMED LOAD REDUCTIONS

Table 86: Sum of Programmed Edge of Stream Phosphorus Load Reductions for the Upper Monocacy

Sum of PLoadEOS	
Row Labels	**Total**
regulated impervious developed	14.4
regulated pervious developed	72.7
Grand Total	**87.1**

IDENTIFIED RESTORATION PROJECTS

Table 87: Summary of all Identified Phosphorus BMPs for the Upper Monocacy

Row Labels	Sum of Total Credited
Bioswale	**30.44**
acres treated	**30.44**
Efficiency	30.44
regulated impervious developed	8.95
regulated pervious developed	21.49
Wet Ponds and Wetlands	**90.11**
acres treated	**90.11**
Efficiency	90.11
regulated impervious developed	16.83
regulated pervious developed	73.28

IDENTIFIED LOAD REDUCTIONS

Table 88: Sum of Identified Edge of Stream Phosphorus Load Reductions for the Upper Monocacy

Row Labels	Total
regulated impervious developed	42.1
regulated pervious developed	29.1
Grand Total	**71.2**

POTENTIAL PROJECTS

Table 89: Summary of all Potential Phosphorus BMPs for the Upper Monocacy

Row Labels	Sum of Total Credited
Bioswale	10
acres treated	10
Efficiency	10
regulated impervious developed	3.5
regulated pervious developed	6.5
Forest Buffers	132
acres in buffers	132
Efficiency	66
regulated impervious developed	7.95
regulated pervious developed	58.05
Landuse Change	66
regulated pervious developed	66
Stream Restoration	2400
feet	2400
Pound Reduction	2400
regulated pervious developed	2400

POTENTIAL LOAD REDUCTIONS

Table 90: Sum of Potential Edge of Stream Phosphorus Load Reductions for the Lower Monocacy

Row Labels	Total
regulated impervious developed	18.9
regulated pervious developed	222.3
Grand Total	**241.2**

COMPLETED RESTORATION PROJECTS

The table below shows all projects in the Catoctin Creek that are Completed for sediment.

Table 91: Summary of all Completed Sediment BMPs Implemented for Catoctin Creek

Row Labels	Sum of Total Credited
Bioretention/rain gardens - A/B soils, no underdrain	0.25
acres treated	0.25
Efficiency	0.25
regulated pervious developed	0.25
Forest Buffers	11.32
acres in buffers	11.32
Efficiency	5.66
regulated impervious developed	0.99
regulated pervious developed	4.67
Landuse Change	5.66
regulated pervious developed	5.66
Grass Buffers	1.2
acres in buffers	1.2
Landuse Change	1.2
regulated pervious developed	1.2
Permeable Pavement w/ Sand, Veg. - A/B soils, no underdrain	0.5
acres treated	0.5
Efficiency	0.5
regulated impervious developed	0.5
Tree Planting	3.45
acres	3.45
Landuse Change	3.45

regulated pervious developed	3.45

COMPLETED LOAD REDUCTIONS

Table 92: Sum of Completed Edge of Stream Sediment Load Reductions for Catoctin Creek

Row Labels	Sum of SLoadEOS
regulated impervious developed	2022
regulated pervious developed	4269
Grand Total	**6291**

PROGRAMMED RESTORATION PROJECTS

Table 93: Summary of all Programmed Sediment BMPs for Catoctin Creek

Row Labels	Sum of Total Credited
Bioretention/rain gardens - A/B soils, no underdrain	**30**
acres treated	**30**
Efficiency	30
regulated impervious developed	8
regulated pervious developed	22
Forest Buffers	**100**
acres in buffers	**100**
Efficiency	50
regulated impervious developed	8.85
regulated pervious developed	41.15
Landuse Change	50
regulated pervious developed	50

PROGRAMMED LOAD REDUCTIONS

Table 94: Sum of Programmed Edge of Stream Sediment Load Reductions for Catoctin Creek

Row Labels	Sum of SLoadEOS

regulated impervious developed	25677
regulated pervious developed	32761
Grand Total	**58438**

IDENTIFIED RESTORATION PROJECTS

Table 95: Summary of all Identified Sediment BMPs for the Catoctin Creek

Row Labels	Sum of Total Credited
Bioswale	**44.56**
acres treated	**44.56**
Efficiency	44.56
regulated impervious developed	12.23
regulated pervious developed	32.33
Wet Ponds and Wetlands	**205.49**
acres treated	**205.49**
Efficiency	205.49
regulated impervious developed	28.68
regulated pervious developed	176.81

IDENTIFIED LOAD REDUCTIONS

Table 96: Sum of Identified Edge of Stream Sediment Load Reductions for Catoctin Creek

Row Labels	Total
regulated impervious developed	60740
regulated pervious developed	47691
Grand Total	**108431**

POTENTIAL PROJECTS

Table 97: Summary of all Potential Sediment BMPs for Catoctin Creek

Row Labels	Sum of Total Credited
Bioswale	140

acres treated	140
Efficiency	140
regulated impervious developed	49
regulated pervious developed	91
Forest Buffers	1260
acres in buffers	1260
Efficiency	630
regulated impervious developed	123.63
regulated pervious developed	506.37
Landuse Change	630
regulated pervious developed	630
Stream Restoration	36000
feet	36000
Pound Reduction	36000
regulated impervious developed	7200
regulated pervious developed	28800

POTENTIAL LOAD REDUCTIONS

Table 98: Sum of Potential Edge of Stream Sediment Load Reductions for Catoctin Creek

Row Labels	Total
regulated impervious developed	535531
regulated pervious developed	1633538.3
Grand Total	**2169069.3**

APPENDIX 10: CATOCTIN CREEK PHOSPHORUS SCENARIOS

COMPLETED RESTORATION PROJECTS

The table below shows all projects in the Catoctin Creek that are Completed for phosphorus.

Table 99: Summary of all Completed Sediment BMPs Implemented for Catoctin Creek

Row Labels	Sum of Total Credited
Bioretention/rain gardens - A/B soils, no underdrain	0.25
acres treated	0.25
Efficiency	0.25
regulated pervious developed	0.25
Forest Buffers	11.32
acres in buffers	11.32
Efficiency	5.66
regulated impervious developed	0.96
regulated pervious developed	4.7
Landuse Change	5.66
regulated pervious developed	5.66
Grass Buffers	2.41
acres in buffers	2.41
Landuse Change	2.41
regulated pervious developed	2.41
Permeable Pavement w/ Sand, Veg. - A/B soils, no underdrain	0.5
acres treated	0.5
Efficiency	0.5
regulated impervious developed	0.5
Tree Planting	4.14
acres	4.14

Landuse Change	4.14
regulated pervious developed	4.14

COMPLETED LOAD REDUCTIONS

Table 100: Sum of Completed Edge of Stream Phosphorus Load Reductions for Catoctin Creek

Row Labels	Sum of PLoadEOS
regulated impervious developed	2.7
regulated pervious developed	7.9
Grand Total	**10.6**

PROGRAMMED RESTORATION PROJECTS

Table 101: Summary of all Programmed Phosphorus BMPs Implemented for Catoctin Creek

Row Labels	Sum of Total Credited
Bioretention/rain gardens - A/B soils, no underdrain	**30**
acres treated	**30**
Efficiency	30
regulated impervious developed	8
regulated pervious developed	22
Forest Buffers	**100**
acres in buffers	**100**
Efficiency	50
regulated impervious developed	8.58
regulated pervious developed	41.42
Landuse Change	50
regulated pervious developed	50

PROGRAMMED LOAD REDUCTIONS

Table 102: Sum of Programmed Edge of Stream Phosphorus Load Reductions for Catoctin Creek

Row Labels	Sum of PLoadEOS
regulated impervious developed	33.9
regulated pervious developed	57.3
Grand Total	**91.2**

IDENTIFIED RESTORATION PROJECTS

Table 103: Summary of all Identified Phosphorus BMPs for Catoctin Creek

Row Labels	Sum of Total Credited
Bioswale	**44.56**
acres treated	**44.56**
Efficiency	44.56
regulated impervious developed	12.23
regulated pervious developed	32.33
Wet Ponds and Wetlands	**205.49**
acres treated	**205.49**
Efficiency	205.49
regulated impervious developed	28.68
regulated pervious developed	176.81

IDENTIFIED LOAD REDUCTIONS

Table 104: Sum of Identified Edge of Stream Phosphorus Load Reductions for Catoctin Creek

Row Labels	Total
regulated impervious developed	68.6
regulated pervious developed	67.2
Grand Total	**135.8**

POTENTIAL PROJECTS

Table 105: Summary of all Potential Phosphorus BMPs for Catoctin Creek

Row Labels	Sum of Total Credited
Bioswale	30
acres treated	30
Efficiency	30
regulated impervious developed	10.5
regulated pervious developed	19.5
Forest Buffers	336
acres in buffers	336
Efficiency	168
CSS impervious developed	0
CSS pervious developed	0
nonregulated impervious developed	0
nonregulated pervious developed	0
regulated impervious developed	29.64
regulated pervious developed	138.36
Landuse Change	168
regulated pervious developed	168
Stream Restoration	8400
feet	8400
Pound Reduction	8400
regulated impervious developed	1200
regulated pervious developed	7200

POTENTIAL LOAD REDUCTIONS

Table 106: Sum of Potential Edge of Stream Phosphorus Load Reductions for Catoctin Creek

Row Labels	Total
regulated impervious developed	149.1
regulated pervious developed	649.7

Grand Total	**798.8**

APPENDIX 11: DOUBLE PIPE CREEK SEDIMENT SCENARIOS

COMPLETED RESTORATION PROJECTS

The table below shows all projects in the Double Pipe Creek that are Completed for sediment.

Table 107: Summary of all Completed Sediment BMPs Implemented for Double Pipe Creek

Row Labels	Sum of Total Credited
Grand Total	**0**

COMPLETED LOAD REDUCTIONS

Table 108: Sum of Completed Edge of Stream Sediment Load Reductions for Double Pipe Creek

Row Labels	Total
regulated impervious developed	0
regulated pervious developed	0
Grand Total	**0**

PROGRAMMED RESTORATION PROJECTS

Table 109: Summary of all Programmed Sediment BMPs for Double Pipe Creek

Row Labels	Sum of Total Credited
Forest Buffers	**22**
acres in buffers	**22**
Efficiency	11
regulated impervious developed	1.72
regulated pervious developed	9.28
Landuse Change	11
regulated pervious developed	11
Grand Total	**22**

PROGRAMMED LOAD REDUCTIONS

Table 110: Sum of Programmed Edge of Stream Sediment Load Reductions for Double Pipe Creek

Row Labels	Total
regulated impervious developed	1475.4
regulated pervious developed	4450.4
Grand Total	**5925.8**

IDENTIFIED RESTORATION PROJECTS

Table 111: Summary of all Identified Sediment BMPs for the Double Pipe Creek

Row Labels	Sum of Total Credited
Bioswale	**11.42**
acres treated	**11.42**
Efficiency	11.42
regulated impervious developed	4.36
regulated pervious developed	7.06
Grand Total	**11.42**

IDENTIFIED LOAD REDUCTIONS

Table 112: Sum of Identified Edge of Stream Sediment Load Reductions for Double Pipe Creek

Row Labels	Total
regulated impervious developed	6217.6
regulated pervious developed	1538
Grand Total	**7755.6**

POTENTIAL PROJECTS

Table 113: Summary of all Potential Sediment BMPs for Double Pipe Creek

Row Labels	Sum of Total Credited
Forest Buffers	168

acres in buffers	168
Efficiency	84
regulated impervious developed	14.54
regulated pervious developed	69.46
Landuse Change	84
regulated pervious developed	84
Stream Restoration	4800
feet	4800
Pound Reduction	4800
regulated pervious developed	4800
Grand Total	**4968**

POTENTIAL LOAD REDUCTIONS

Table 114: Sum of Potential Edge of Stream Sediment Load Reductions for Double Pipe Creek

Row Labels	Total
regulated impervious developed	12168.8
regulated pervious developed	229345.3
Grand Total	**241514.1**

APPENDIX 12: DOUBLE PIPE CREEK PHOSPHORUS SCENARIOS

COMPLETED RESTORATION PROJECTS

The table below shows all projects in the Double Pipe Creek that are Completed for phosphorus.

Table 115: Summary of all Completed Sediment BMPs Implemented for Double Pipe Creek

Row Labels	Sum of Total Credited
Grand Total	**0**

COMPLETED LOAD REDUCTIONS

Table 116: Sum of Completed Edge of Stream Phosphorus Load Reductions for Double Pipe Creek

Land Use	Sum of PLoadEOS
regulated impervious developed	0
regulated pervious developed	0
Grand Total	**0**

PROGRAMMED RESTORATION PROJECTS

Table 117: Summary of all Programmed Phosphorus BMPs Implemented for Double Pipe Creek

Row Labels	Sum of Total Credited
Forest Buffers	**22**
acres in buffers	**22**
Efficiency	11
regulated impervious developed	1.87
regulated pervious developed	9.13
Landuse Change	11
regulated pervious developed	11

PROGRAMMED LOAD REDUCTIONS

Table 118: Sum of Programmed Edge of Stream Phosphorus Load Reductions for Double Pipe Creek

Row Labels	Total
regulated impervious developed	2.6
regulated pervious developed	8.9
Grand Total	**11.5**

IDENTIFIED RESTORATION PROJECTS

Table 119: Summary of all Identified Phosphorus BMPs for Double Pipe Creek

Row Labels	Sum of Total Credited
Bioswale	**11.42**
acres treated	**11.42**
Efficiency	11.42
regulated impervious developed	4.36
regulated pervious developed	7.06

IDENTIFIED LOAD REDUCTIONS

Table 120: Sum of Identified Edge of Stream Phosphorus Load Reductions for Double Pipe Creek

Row Labels	Total
regulated impervious developed	9.4
regulated pervious developed	2.9
Grand Total	**12.3**

POTENTIAL PROJECTS

Table 121: Summary of all Potential Phosphorus BMPs for Double Pipe Creek

Row Labels	Sum of Total Credited
Bioswale	50
acres treated	50

Efficiency	50
regulated impervious developed	17.5
regulated pervious developed	32.5
Forest Buffers	446.26
acres in buffers	446.26
Efficiency	232.26
regulated impervious developed	43.21
regulated pervious developed	189.05
Landuse Change	214
regulated pervious developed	214
Stream Restoration	12000
feet	12000
Pound Reduction	12000
regulated impervious developed	2400
regulated pervious developed	9600

POTENTIAL LOAD REDUCTIONS

Table 122: Sum of Potential Edge of Stream Phosphorus Load Reductions for Double Pipe Creek

Row Labels	Total
regulated impervious developed	257.9
regulated pervious developed	652.8
Grand Total	**910.7**

APPENDIX 13: POTOMAC DIRECT SEDIMENT SCENARIOS

COMPLETED RESTORATION PROJECTS

The table below shows all projects in the Potomac Direct that are Completed for sediment.

Table 123: Summary of all Completed Sediment BMPs Implemented for Potomac Direct

BMP	Total
Tree Planting	0.97
acres	0.97
Landuse Change	0.97
regulated pervious developed	0.97

COMPLETED LOAD REDUCTIONS

Table 124: Sum of Completed Edge of Stream Sediment Load Reductions for Potomac Direct

Land Use	Total
regulated impervious developed	0
regulated pervious developed	284.9
Grand Total	**284.9**

PROGRAMMED RESTORATION PROJECTS

Table 125: Summary of all Programmed Sediment BMPs for Potomac Direct

Row Labels	Sum of Total Credited
Forest Buffers	**38**
acres in buffers	**38**
Efficiency	19
regulated impervious developed	5.38
regulated pervious developed	13.62
Landuse Change	19
regulated pervious developed	19

Stream Restoration	**3999.94**
feet	**3999.94**
Pound Reduction	3999.94
regulated pervious developed	3999.94
Wet Ponds and Wetlands	**36.03**
acres treated	**36.03**
Efficiency	36.03
regulated impervious developed	10.2
regulated pervious developed	25.83

PROGRAMMED LOAD REDUCTIONS

Table 126: Sum of Programmed Edge of Stream Sediment Load Reductions for Potomac Direct

Row Labels	Total
regulated impervious developed	12821.3
regulated pervious developed	13191.7
Grand Total	**26013**

IDENTIFIED RESTORATION PROJECTS

The TMDL was reached in the past phase.

IDENTIFIED LOAD REDUCTIONS

The TMDL was reached in the past phase.

POTENTIAL PROJECTS

The TMDL was reached in the past phase.

POTENTIAL LOAD REDUCTIONS

The TMDL was reached in the past phase.

APPENDIX 14: CHESAPEAKE BAY NITROGEN SCENARIOS

COMPLETED RESTORATION PROJECTS

Table 127: Summary of all Completed Nitrogen BMPs Implemented for the Chesapeake Bay

Row Labels	acres	acres in buffers	acres treated	feet
Bioretention/raingardens - A/B soils, no underdrain			**0.73**	
Efficiency			**0.73**	
County Phase I/II MS4 Impervious			0.26	
County Phase I/II MS4 Pervious			0.47	
Bioretention/raingardens - A/B soils, underdrain			**11.71**	
Efficiency			**11.71**	
County Phase I/II MS4 Impervious			2.58	
County Phase I/II MS4 Pervious			9.13	
Bioretention/raingardens - C/D soils, underdrain			**0**	
Efficiency			**0**	
County Phase I/II MS4 Impervious			0	
County Phase I/II MS4 Pervious			0	
Bioswale			**3.83**	
Efficiency			**3.83**	
County Phase I/II MS4 Impervious			3.83	
County Phase I/II MS4 Pervious			0	
Dry Detention Ponds and Hydrodynamic Structures			**0**	
Efficiency			**0**	
County Phase I/II MS4 Impervious			0	
County Phase I/II MS4 Pervious			0	
Dry Extended Detention Ponds			**0**	
Efficiency			**0**	
County Phase I/II MS4 Impervious			0	
County Phase I/II MS4 Pervious			0	
Filtering Practices			**0**	
Efficiency			**0**	
County Phase I/II MS4 Impervious			0	
County Phase I/II MS4 Pervious			0	
Forest Buffers		**181**		
Efficiency		**80.13**		
County Phase I/II MS4 Impervious		14.67		
County Phase I/II MS4 Pervious		65.46		
Landuse Change		**100.87**		
County Phase I/II MS4 Pervious		100.87		
Grass Buffers		**15.73**		

Landuse Change		**15.73**		
County Phase I/II MS4 Pervious		15.73		
Infiltration Practices w/ Sand, Veg. - A/B soils, no underdrain			**0**	
Efficiency			**0**	
County Phase I/II MS4 Impervious			0	
County Phase I/II MS4 Pervious			0	
Infiltration Practices w/o Sand, Veg. - A/B soils, no underdrain			**0.01**	
Efficiency			**0.01**	
County Phase I/II MS4 Impervious			0.01	
County Phase I/II MS4 Pervious			0	
Permeable Pavement w/ Sand, Veg. - A/B soils, no underdrain			**0.5**	
Efficiency			**0.5**	
County Phase I/II MS4 Impervious			0.5	
Stream Restoration				**1105**
Pound Reduction				**1105**
County Phase I/II MS4 Pervious				1105
Tree Planting	**22.95**			
Landuse Change	**22.95**			
County Phase I/II MS4 Pervious	22.95			
Vegetated Open Channels - A/B soils, no underdrain			**0**	
Efficiency			**0**	
County Phase I/II MS4 Impervious			0	
County Phase I/II MS4 Pervious			0	
Vegetated Open Channels - C/D soils, no underdrain			**0**	
Efficiency			**0**	
County Phase I/II MS4 Impervious			0	
County Phase I/II MS4 Pervious			0	
Wet Ponds and Wetlands			**28.7**	
Efficiency			**28.7**	
County Phase I/II MS4 Impervious			25.16	
County Phase I/II MS4 Pervious			3.54	
Grand Total	**22.95**	**196.73**	**45.48**	**1105**

COMPLETED LAND USE LOADS

Table 128: Summary of Completed Scenario Land Use Loads by Subwatershed for Nitrogen to the Chesapeake Bay

Row Labels	Sum of Acres	Sum of NLoadEOS	Sum of NLoadDEL

Catoctin Creek	**7653.64**	**177180.44**	**57793.87**
County Phase I/II MS4 Impervious	1300.95	38330.31	11419.15
County Phase I/II MS4 Pervious	6352.69	138850.13	46374.72
Double Pipe Creek	**1427.22**	**30387.6**	**7554.76**
County Phase I/II MS4 Impervious	240.86	6903.27	1728.42
County Phase I/II MS4 Pervious	1186.36	23484.33	5826.34
Lower Monocacy River	**31835.76**	**648796.69**	**365605.72**
County Phase I/II MS4 Impervious	5715.73	150670.87	86154.99
County Phase I/II MS4 Pervious	26120.03	498125.82	279450.73
Potomac River FR Cnty	**3656.79**	**78001.66**	**57482.75**
County Phase I/II MS4 Impervious	697.71	19253.45	14203.87
County Phase I/II MS4 Pervious	2959.08	58748.21	43278.88
Potomac River MO Cnty	**53**	**1144.09**	**886.3**
County Phase I/II MS4 Impervious	9	260.71	201.96
County Phase I/II MS4 Pervious	44	883.38	684.34
Upper Monocacy River	**7532.97**	**159946.06**	**66818.89**
County Phase I/II MS4 Impervious	879.19	25398.27	10171.7
County Phase I/II MS4 Pervious	6653.78	134547.79	56647.19
Grand Total	**52159.38**	**1095456.54**	**556142.29**

COMPLETED LOAD REDUCTIONS

Table 129: Sum of Completed Edge of Stream and Delivered Nitrogen Load Reductions for the Chesapeake Bay Watershed

Row Labels	Sum of NLoadEOS	Sum of NLoadDEL
Catoctin Creek	**16.61**	**5.11**
County Phase I/II MS4 Impervious	12.12	3.61
County Phase I/II MS4 Pervious	4.49	1.5
Double Pipe Creek	**0**	**0**
County Phase I/II MS4 Impervious	0	0
County Phase I/II MS4 Pervious	0	0
Lower Monocacy River	**967.36**	**540.86**
County Phase I/II MS4 Impervious	295.78	168.92
County Phase I/II MS4 Pervious	671.58	371.94
Potomac River FR Cnty	**0**	**0**
County Phase I/II MS4 Impervious	0	0
County Phase I/II MS4 Pervious	0	0
Potomac River MO Cnty	**0**	**0**
County Phase I/II MS4 Impervious	0	0
County Phase I/II MS4 Pervious	0	0
Upper Monocacy River	**17.94**	**6.42**
County Phase I/II MS4 Impervious	53.91	21.57

County Phase I/II MS4 Pervious	-35.97	-15.15
Grand Total	**1001.91**	**552.39**

PROGRAMMED RESTORATION PROJECTS

Table 130: Summary of all Programmed Nitrogen BMPs Implemented for the Chesapeake Bay

Row Labels	acres	acres in buffers	acres treated	feet
Bioretention/raingardens - A/B soils, no underdrain			**30.78**	
Efficiency			**30.78**	
County Phase I/II MS4 Impervious			8.78	
County Phase I/II MS4 Pervious			22	
Bioswale			**8.12**	
Efficiency			**8.12**	
County Phase I/II MS4 Impervious			8.12	
County Phase I/II MS4 Pervious			0	
Forest Buffers		**457.26**		
Efficiency		**182.26**		
County Phase I/II MS4 Impervious		30.01		
County Phase I/II MS4 Pervious		152.25		
Landuse Change		**275**		
County Phase I/II MS4 Pervious		275		
Stream Restoration				**4000**
Pound Reduction				**4000**
County Phase I/II MS4 Pervious				4000
Wet Ponds and Wetlands			**653.09**	
Efficiency			**653.09**	
County Phase I/II MS4 Impervious			136.03	
County Phase I/II MS4 Pervious			517.06	
Grand Total	**0**	**457.26**	**691.99**	**4000**

PROGRAMMED LAND USE LOADS

Table 131: Summary of Programmed Scenario Land Use Loads by Subwatershed for Nitrogen to the Chesapeake Bay

Row Labels	Sum of Acres	Sum of NLoadEOS	Sum of NLoadDEL
Catoctin Creek	**7653.64**	**176313.81**	**57510.71**
County Phase I/II MS4 Impervious	1300.95	38078.95	11343.63
County Phase I/II MS4 Pervious	6352.69	138234.86	46167.08
Double Pipe Creek	**1427.22**	**30381.34**	**7553.22**
County Phase I/II MS4 Impervious	240.86	6901.85	1728.07
County Phase I/II MS4 Pervious	1186.36	23479.49	5825.15

Lower Monocacy River	**31835.76**	**646423.26**	**364266.21**
County Phase I/II MS4 Impervious	5715.73	149802.9	85658.92
County Phase I/II MS4 Pervious	26120.03	496620.36	278607.29
Potomac River FR Cnty	**3656.79**	**76685.92**	**56513.1**
County Phase I/II MS4 Impervious	697.71	19153.18	14129.9
County Phase I/II MS4 Pervious	2959.08	57532.74	42383.2
Potomac River MO Cnty	**53**	**1144.09**	**886.3**
County Phase I/II MS4 Impervious	9	260.71	201.96
County Phase I/II MS4 Pervious	44	883.38	684.34
Upper Monocacy River	**7532.97**	**159763.96**	**66744.95**
County Phase I/II MS4 Impervious	879.19	25367.45	10159.87
County Phase I/II MS4 Pervious	6653.78	134396.51	56585.08
Grand Total	**52159.38**	**1090712.38**	**553474.49**

PROGRAMMED LOAD REDUCTIONS

Table 132: Sum of Programmed Edge of Stream and Delivered Nitrogen Load Reductions for the Chesapeake Bay Watershed

Row Labels	Sum of NLoadEOS	Sum of NLoadDEL
Catoctin Creek	**866.63**	**283.16**
County Phase I/II MS4 Impervious	251.36	75.52
County Phase I/II MS4 Pervious	615.27	207.64
Double Pipe Creek	**6.26**	**1.54**
County Phase I/II MS4 Impervious	1.42	0.35
County Phase I/II MS4 Pervious	4.84	1.19
Lower Monocacy River	**2373.43**	**1339.51**
County Phase I/II MS4 Impervious	867.97	496.07
County Phase I/II MS4 Pervious	1505.46	843.44
Potomac River FR Cnty	**1315.74**	**969.65**
County Phase I/II MS4 Impervious	100.27	73.97
County Phase I/II MS4 Pervious	1215.47	895.68
Potomac River MO Cnty	**0**	**0**
County Phase I/II MS4 Impervious	0	0
County Phase I/II MS4 Pervious	0	0
Upper Monocacy River	**182.1**	**73.94**
County Phase I/II MS4 Impervious	30.82	11.83
County Phase I/II MS4 Pervious	151.28	62.11
Grand Total	**4744.16**	**2667.8**

IDENTIFIED RESTORATION PROJECTS

Table 133: Summary of all Identified Nitrogen BMPs Implemented for the Chesapeake Bay

Row Labels	acres	acres in buffers	acres treated	feet
Bioretention/raingardens - A/B soils, no underdrain			**686.58**	
Efficiency			**686.58**	
County Phase I/II MS4 Impervious			219.31	
County Phase I/II MS4 Pervious			467.27	
Bioretention/raingardens - A/B soils, underdrain			**94**	
Efficiency			**94**	
County Phase I/II MS4 Impervious			0	
County Phase I/II MS4 Pervious			94	
Bioswale			**262.76**	
Efficiency			**262.76**	
County Phase I/II MS4 Impervious			63.14	
County Phase I/II MS4 Pervious			199.62	
Forest Buffers		**317.81**		
Efficiency		**140.8**		
County Phase I/II MS4 Impervious		25.93		
County Phase I/II MS4 Pervious		114.87		
Landuse Change		**177.01**		
County Phase I/II MS4 Pervious		177.01		
Stream Restoration				**33835**
Pound Reduction				**33835**
County Phase I/II MS4 Pervious				33835
Tree Planting	**0**			
Landuse Change	**0**			
County Phase I/II MS4 Pervious	0			
Wet Ponds and Wetlands			**1323.33**	
Efficiency			**1323.33**	
County Phase I/II MS4 Impervious			326.11	
County Phase I/II MS4 Pervious			997.22	
Grand Total	**0**	**317.81**	**2366.67**	**33835**

IDENTIFIED LAND USE LOADS

Table 134: Summary of Identified Scenario Land Use Loads by Subwatershed for Nitrogen to the Chesapeake Bay

Row Labels	Sum of Acres	Sum of NLoadEOS	Sum of NLoadDEL
Catoctin Creek	**7653.64**	**174733.78**	**56996**
County Phase I/II MS4 Impervious	1300.95	37718.96	11236.38
County Phase I/II MS4 Pervious	6352.69	137014.82	45759.62
Double Pipe Creek	**1427.22**	**30377.07**	**7552.14**

County Phase I/II MS4 Impervious	240.86	6898.76	1727.29
County Phase I/II MS4 Pervious	1186.36	23478.31	5824.85
Lower Monocacy River	**31835.76**	**623135.86**	**351129.32**
County Phase I/II MS4 Impervious	5715.73	142760.02	81632.06
County Phase I/II MS4 Pervious	26120.03	480375.84	269497.26
Potomac River FR Cnty	**3656.79**	**76127.69**	**56101.74**
County Phase I/II MS4 Impervious	697.71	19030.96	14039.74
County Phase I/II MS4 Pervious	2959.08	57096.73	42062
Potomac River MO Cnty	**53**	**1144.09**	**886.3**
County Phase I/II MS4 Impervious	9	260.71	201.96
County Phase I/II MS4 Pervious	44	883.38	684.34
Upper Monocacy River	**7532.97**	**159292.89**	**66549.09**
County Phase I/II MS4 Impervious	879.19	25246.88	10111.59
County Phase I/II MS4 Pervious	6653.78	134046.01	56437.5
Grand Total	**52159.38**	**1064811.38**	**539214.59**

IDENTIFIED LOAD REDUCTIONS

Table 135: Sum of Identified Edge of Stream and Delivered Nitrogen Load Reductions for the Chesapeake Bay Watershed

Row Labels	Sum of NLoadEOS	Sum of NLoadDEL
Catoctin Creek	**1580.03**	**514.71**
County Phase I/II MS4 Impervious	359.99	107.25
County Phase I/II MS4 Pervious	1220.04	407.46
Double Pipe Creek	**4.27**	**1.08**
County Phase I/II MS4 Impervious	3.09	0.78
County Phase I/II MS4 Pervious	1.18	0.3
Lower Monocacy River	**23287.4**	**13136.89**
County Phase I/II MS4 Impervious	7042.88	4026.86
County Phase I/II MS4 Pervious	16244.52	9110.03
Potomac River FR Cnty	**558.23**	**411.36**
County Phase I/II MS4 Impervious	122.22	90.16
County Phase I/II MS4 Pervious	436.01	321.2
Potomac River MO Cnty	**0**	**0**
County Phase I/II MS4 Impervious	0	0
County Phase I/II MS4 Pervious	0	0
Upper Monocacy River	**471.07**	**195.86**
County Phase I/II MS4 Impervious	120.57	48.28
County Phase I/II MS4 Pervious	350.5	147.58
Grand Total	**25901**	**14259.9**

POTENTIAL RESTORATION PROJECTS

Table 136: Summary of all Potential Nitrogen BMPs Implemented for the Chesapeake Bay

Row Labels	acres	acres in buffers	acres treated	feet
Bioretention/raingardens - A/B soils, no underdrain			**1890**	
Efficiency			**1890**	
County Phase I/II MS4 Impervious			480	
County Phase I/II MS4 Pervious			1410	
Bioretention/raingardens - A/B soils, underdrain			**0**	
Efficiency			**0**	
County Phase I/II MS4 Impervious			0	
County Phase I/II MS4 Pervious			0	
Bioswale			**861**	
Efficiency			**861**	
County Phase I/II MS4 Impervious			342.99	
County Phase I/II MS4 Pervious			518.01	
Forest Buffers		**6263.85**		
Efficiency		**2567.86**		
County Phase I/II MS4 Impervious		429.02		
County Phase I/II MS4 Pervious		2138.84		
Landuse Change		**3695.99**		
County Phase I/II MS4 Pervious		3695.99		
Grass Buffers		**0**		
Landuse Change		**0**		
County Phase I/II MS4 Pervious		0		
Stream Restoration				**249600**
Pound Reduction				**249600**
County Phase I/II MS4 Impervious				177599.99
County Phase I/II MS4 Pervious				72000.01
Wet Ponds and Wetlands			**3000.01**	
Efficiency			**3000.01**	
County Phase I/II MS4 Impervious			1000	
County Phase I/II MS4 Pervious			2000.01	
Grand Total	**0**	**6263.85**	**5751.01**	**249600**

POTENTIAL LAND USE LOADS

Table 137: Summary of Potential Scenario Land Use Loads by Subwatershed for Nitrogen to the Chesapeake Bay

Row Labels	Sum of Acres	Sum of NLoadEOS	Sum of NLoadDEL
Catoctin Creek	**7653.64**	**167072**	**54504.11**
County Phase I/II MS4 Impervious	1300.95	35177.23	10473.61
County Phase I/II MS4 Pervious	6352.69	131894.77	44030.5

Double Pipe Creek	**1427.22**	**29717.89**	**7387.7**
County Phase I/II MS4 Impervious	240.86	6483.72	1623.39
County Phase I/II MS4 Pervious	1186.36	23234.17	5764.31
Lower Monocacy River	**31835.76**	**555804.52**	**313074.87**
County Phase I/II MS4 Impervious	5715.73	114613.14	65540.98
County Phase I/II MS4 Pervious	26120.03	441191.38	247533.89
Potomac River FR Cnty	**3656.79**	**76127.69**	**56101.74**
County Phase I/II MS4 Impervious	697.71	19030.96	14039.74
County Phase I/II MS4 Pervious	2959.08	57096.73	42062
Potomac River MO Cnty	**53**	**1144.09**	**886.3**
County Phase I/II MS4 Impervious	9	260.71	201.96
County Phase I/II MS4 Pervious	44	883.38	684.34
Upper Monocacy River	**7532.97**	**153151.39**	**64046.82**
County Phase I/II MS4 Impervious	879.19	21987.89	8810.69
County Phase I/II MS4 Pervious	6653.78	131163.5	55236.13
Grand Total	**52159.38**	**983017.58**	**496001.54**

POTENTIAL LOAD REDUCTIONS

Table 138: Sum of Potential Edge of Stream and Delivered Nitrogen Load Reductions for the Chesapeake Bay Watershed

Row Labels	Sum of NLoadEOS	Sum of NLoadDEL
Catoctin Creek	**7661.78**	**2491.89**
County Phase I/II MS4 Impervious	2541.73	762.77
County Phase I/II MS4 Pervious	5120.05	1729.12
Double Pipe Creek	**659.18**	**164.44**
County Phase I/II MS4 Impervious	415.04	103.9
County Phase I/II MS4 Pervious	244.14	60.54
Lower Monocacy River	**67331.34**	**38054.45**
County Phase I/II MS4 Impervious	28146.88	16091.08
County Phase I/II MS4 Pervious	39184.46	21963.37
Potomac River FR Cnty	**0**	**0**
County Phase I/II MS4 Impervious	0	0
County Phase I/II MS4 Pervious	0	0
Potomac River MO Cnty	**0**	**0**
County Phase I/II MS4 Impervious	0	0
County Phase I/II MS4 Pervious	0	0
Upper Monocacy River	**6141.5**	**2502.27**
County Phase I/II MS4 Impervious	3258.99	1300.9
County Phase I/II MS4 Pervious	2882.51	1201.37
Grand Total	**81793.8**	**43213.05**

APPENDIX 15: CHESAPEAKE BAY PHOSPHORUS SCENARIOS

COMPLETED RESTORATION PROJECTS

Table 139: Summary of all Completed Phosphorus BMPs Implemented for the Chesapeake Bay

Row Labels	acres	acres in buffers	acres treated	feet
Bioretention/raingardens - A/B soils, no underdrain			**0.73**	
Efficiency			**0.73**	
County Phase I/II MS4 Impervious			0.26	
County Phase I/II MS4 Pervious			0.47	
Bioretention/raingardens - A/B soils, underdrain			**11.71**	
Efficiency			**11.71**	
County Phase I/II MS4 Impervious			2.58	
County Phase I/II MS4 Pervious			9.13	
Bioswale			**3.83**	
Efficiency			**3.83**	
County Phase I/II MS4 Impervious			3.83	
County Phase I/II MS4 Pervious			0	
Forest Buffers		**181**		
Efficiency		**80.13**		
County Phase I/II MS4 Impervious		14.67		
County Phase I/II MS4 Pervious		65.46		
Landuse Change		**100.87**		
County Phase I/II MS4 Pervious		100.87		
Grass Buffers		**15.73**		
Landuse Change		**15.73**		
County Phase I/II MS4 Pervious		15.73		
Infiltration Practices w/o Sand, Veg. - A/B soils, no underdrain			**0.01**	
Efficiency			**0.01**	
County Phase I/II MS4 Impervious			0.01	
County Phase I/II MS4 Pervious			0	
Permeable Pavement w/ Sand, Veg. - A/B soils, no underdrain			**0.5**	
Efficiency			**0.5**	
County Phase I/II MS4 Impervious			0.5	
Stream Restoration				**1105**
Pound Reduction				**1105**
County Phase I/II MS4 Pervious				1105
Tree Planting	**22.95**			
Landuse Change	**22.95**			

County Phase I/II MS4 Pervious	22.95			
Wet Ponds and Wetlands			**28.7**	
Efficiency			**28.7**	
County Phase I/II MS4 Impervious			25.16	
County Phase I/II MS4 Pervious			3.54	
Grand Total	**22.95**	**196.73**	**45.48**	**1105**

COMPLETED LAND USE LOADS

Table 140: Summary of Completed Scenario Land Use Loads by Subwatershed for Phosphorus to the Chesapeake Bay

Row Labels	Sum of Acres	Sum of PLoadEOS	Sum of PLoadDEL
Catoctin Creek	**7653.64**	**7792.42**	**3655.68**
County Phase I/II MS4 Impervious	1300.95	3901.49	1830.32
County Phase I/II MS4 Pervious	6352.69	3890.93	1825.36
Double Pipe Creek	**1427.22**	**1350.35**	**633.49**
County Phase I/II MS4 Impervious	240.86	685.9	321.78
County Phase I/II MS4 Pervious	1186.36	664.45	311.71
Lower Monocacy River	**31835.76**	**27877.65**	**13078.31**
County Phase I/II MS4 Impervious	5715.73	14290.32	6704.05
County Phase I/II MS4 Pervious	26120.03	13587.33	6374.26
Potomac River FR Cnty	**3656.79**	**3422.87**	**1605.76**
County Phase I/II MS4 Impervious	697.71	1853.75	869.65
County Phase I/II MS4 Pervious	2959.08	1569.12	736.11
Potomac River MO Cnty	**53**	**51.1**	**23.97**
County Phase I/II MS4 Impervious	9	25.94	12.17
County Phase I/II MS4 Pervious	44	25.16	11.8
Upper Monocacy River	**7532.97**	**6348.29**	**2978.2**
County Phase I/II MS4 Impervious	879.19	2551.32	1196.91
County Phase I/II MS4 Pervious	6653.78	3796.97	1781.29
Grand Total	**52159.38**	**46842.68**	**21975.41**

COMPLETED LOAD REDUCTIONS

Table 141: Sum of Completed Edge of Stream and Delivered Phosphorus Load Reductions for the Chesapeake Bay Watershed

Row Labels	Sum of PLoadEOS	Sum of PLoadDEL
Catoctin Creek	**1.38**	**0.65**
County Phase I/II MS4 Impervious	1.25	0.59
County Phase I/II MS4 Pervious	0.13	0.06
Double Pipe Creek	**0**	**0**

County Phase I/II MS4 Impervious	0	
County Phase I/II MS4 Pervious	0	0
Lower Monocacy River	**145.66**	**68.35**
County Phase I/II MS4 Impervious	54.2	25.44
County Phase I/II MS4 Pervious	91.46	42.91
Potomac River FR Cnty	**0**	**0**
County Phase I/II MS4 Impervious	0	0
County Phase I/II MS4 Pervious	0	0
Potomac River MO Cnty	**0**	**0**
County Phase I/II MS4 Impervious	0	0
County Phase I/II MS4 Pervious	0	0
Upper Monocacy River	**4.86**	**2.26**
County Phase I/II MS4 Impervious	5.89	2.76
County Phase I/II MS4 Pervious	-1.03	-0.5
Grand Total	**151.9**	**71.26**

PROGRAMMED RESTORATION PROJECTS

Table 142: Summary of all Programmed Phosphorus BMPs Implemented for the Chesapeake Bay

Row Labels	acres	acres in buffers	acres treated	feet
Bioretention/raingardens - A/B soils, no underdrain			**30.78**	
Efficiency			**30.78**	
County Phase I/II MS4 Impervious			8.78	
County Phase I/II MS4 Pervious			22	
Bioswale			**8.12**	
Efficiency			**8.12**	
County Phase I/II MS4 Impervious			8.12	
County Phase I/II MS4 Pervious			0	
Forest Buffers		**457.26**		
Efficiency		**182.26**		
County Phase I/II MS4 Impervious		30.01		
County Phase I/II MS4 Pervious		152.25		
Landuse Change		**275**		
County Phase I/II MS4 Pervious		275		
Stream Restoration				**4000**
Pound Reduction				**4000**
County Phase I/II MS4 Pervious				4000
Wet Ponds and Wetlands			**653.09**	
Efficiency			**653.09**	
County Phase I/II MS4 Impervious			136.03	
County Phase I/II MS4 Pervious			517.06	

Grand Total	0	457.26	691.99	4000

PROGRAMMED LAND USE LOADS

Table 143: Summary of Programmed Scenario Land Use Loads by Subwatershed for Phosphorus to the Chesapeake Bay

Row Labels	Sum of Acres	Sum of PLoadEOS	Sum of PLoadDEL
Catoctin Creek	**7653.64**	**7735.37**	**3628.92**
County Phase I/II MS4 Impervious	1300.95	3868.58	1814.88
County Phase I/II MS4 Pervious	6352.69	3866.79	1814.04
Double Pipe Creek	**1427.22**	**1349.8**	**633.23**
County Phase I/II MS4 Impervious	240.86	685.62	321.64
County Phase I/II MS4 Pervious	1186.36	664.18	311.59
Lower Monocacy River	**31835.76**	**27611.13**	**12953.28**
County Phase I/II MS4 Impervious	5715.73	14116.84	6622.67
County Phase I/II MS4 Pervious	26120.03	13494.29	6330.61
Potomac River FR Cnty	**3656.79**	**3070.77**	**1440.61**
County Phase I/II MS4 Impervious	697.71	1832.85	859.85
County Phase I/II MS4 Pervious	2959.08	1237.92	580.76
Potomac River MO Cnty	**53**	**51.1**	**23.97**
County Phase I/II MS4 Impervious	9	25.94	12.17
County Phase I/II MS4 Pervious	44	25.16	11.8
Upper Monocacy River	**7532.97**	**6333.65**	**2971.32**
County Phase I/II MS4 Impervious	879.19	2545.15	1194.01
County Phase I/II MS4 Pervious	6653.78	3788.5	1777.31
Grand Total	**52159.38**	**46151.82**	**21651.33**

PROGRAMMED LOAD REDUCTIONS

Table 144: Sum of Programmed Edge of Stream and Delivered Phosphorus Load Reductions for the Chesapeake Bay Watershed

Row Labels	Sum of PLoadEOS	Sum of PLoadDEL
Catoctin Creek	**57.05**	**26.76**
County Phase I/II MS4 Impervious	32.91	15.44
County Phase I/II MS4 Pervious	24.14	11.32
Double Pipe Creek	**0.55**	**0.26**
County Phase I/II MS4 Impervious	0.28	0.14
County Phase I/II MS4 Pervious	0.27	0.12
Lower Monocacy River	**266.52**	**125.03**
County Phase I/II MS4 Impervious	173.48	81.38
County Phase I/II MS4 Pervious	93.04	43.65
Potomac River FR Cnty	**352.1**	**165.15**

County Phase I/II MS4 Impervious	20.9	9.8
County Phase I/II MS4 Pervious	331.2	155.35
Potomac River MO Cnty	**0**	**0**
County Phase I/II MS4 Impervious	0	0
County Phase I/II MS4 Pervious	0	0
Upper Monocacy River	**14.64**	**6.88**
County Phase I/II MS4 Impervious	6.17	2.9
County Phase I/II MS4 Pervious	8.47	3.98
Grand Total	**690.86**	**324.08**

IDENTIFIED RESTORATION PROJECTS

Table 145: Summary of all Identified Phosphorus BMPs Implemented for the Chesapeake Bay

Row Labels	acres	acres in buffers	acres treated	feet
Bioretention/raingardens - A/B soils, no underdrain			**686.58**	
Efficiency			**686.58**	
County Phase I/II MS4 Impervious			219.31	
County Phase I/II MS4 Pervious			467.27	
Bioretention/raingardens - A/B soils, underdrain			**94**	
Efficiency			**94**	
County Phase I/II MS4 Impervious			0	
County Phase I/II MS4 Pervious			94	
Bioswale			**262.76**	
Efficiency			**262.76**	
County Phase I/II MS4 Impervious			63.14	
County Phase I/II MS4 Pervious			199.62	
Forest Buffers		**317.81**		
Efficiency		**140.8**		
County Phase I/II MS4 Impervious		25.93		
County Phase I/II MS4 Pervious		114.87		
Landuse Change		**177.01**		
County Phase I/II MS4 Pervious		177.01		
Stream Restoration				**33835**
Pound Reduction				**33835**
County Phase I/II MS4 Pervious				33835
Wet Ponds and Wetlands			**1323.33**	
Efficiency			**1323.33**	
County Phase I/II MS4 Impervious			326.11	

County Phase I/II MS4 Pervious			997.22	
Grand Total	**0**	**317.81**	**2366.67**	**33835**

IDENTIFIED LAND USE LOADS

Table 146: Summary of Identified Scenario Land Use Loads by Subwatershed for Phosphorus to the Chesapeake Bay

Row Labels	Sum of Acres	Sum of PLoadEOS	Sum of PLoadDEL
Catoctin Creek	**7653.64**	**7610.14**	**3570.17**
County Phase I/II MS4 Impervious	1300.95	3807.68	1786.31
County Phase I/II MS4 Pervious	6352.69	3802.46	1783.86
Double Pipe Creek	**1427.22**	**1349.44**	**633.06**
County Phase I/II MS4 Impervious	240.86	685.29	321.49
County Phase I/II MS4 Pervious	1186.36	664.15	311.57
Lower Monocacy River	**31835.76**	**24008.73**	**11263.28**
County Phase I/II MS4 Impervious	5715.73	13197.51	6191.37
County Phase I/II MS4 Pervious	26120.03	10811.22	5071.91
Potomac River FR Cnty	**3656.79**	**3022.12**	**1417.77**
County Phase I/II MS4 Impervious	697.71	1808.86	848.6
County Phase I/II MS4 Pervious	2959.08	1213.26	569.17
Potomac River MO Cnty	**53**	**51.1**	**23.97**
County Phase I/II MS4 Impervious	9	25.94	12.17
County Phase I/II MS4 Pervious	44	25.16	11.8
Upper Monocacy River	**7532.97**	**6289.54**	**2950.63**
County Phase I/II MS4 Impervious	879.19	2521.77	1183.04
County Phase I/II MS4 Pervious	6653.78	3767.77	1767.59
Grand Total	**52159.38**	**42331.07**	**19858.88**

IDENTIFIED LOAD REDUCTIONS

Table 147: Sum of Identified Edge of Stream and Delivered Phosphorus Load Reductions for the Chesapeake Bay Watershed

Row Labels	Sum of PLoadEOS	Sum of PLoadDEL
Catoctin Creek	**125.23**	**58.75**
County Phase I/II MS4 Impervious	60.9	28.57
County Phase I/II MS4 Pervious	64.33	30.18
Double Pipe Creek	**0.36**	**0.17**
County Phase I/II MS4 Impervious	0.33	0.15
County Phase I/II MS4 Pervious	0.03	0.02
Lower Monocacy River	**3602.4**	**1690**
County Phase I/II MS4 Impervious	919.33	431.3
County Phase I/II MS4 Pervious	2683.07	1258.7

Potomac River FR Cnty	**48.65**	**22.84**
County Phase I/II MS4 Impervious	23.99	11.25
County Phase I/II MS4 Pervious	24.66	11.59
Potomac River MO Cnty	**0**	**0**
County Phase I/II MS4 Impervious	0	0
County Phase I/II MS4 Pervious	0	0
Upper Monocacy River	**44.11**	**20.69**
County Phase I/II MS4 Impervious	23.38	10.97
County Phase I/II MS4 Pervious	20.73	9.72
Grand Total	**3820.75**	**1792.45**

POTENTIAL RESTORATION PROJECTS

Table 148: Summary of all Potential Phosphorus BMPs Implemented for the Chesapeake Bay

Row Labels	acres	acres in buffers	acres treated	feet
Bioretention/raingardens - A/B soils, no underdrain			**1890**	
Efficiency			**1890**	
County Phase I/II MS4 Impervious			480	
County Phase I/II MS4 Pervious			1410	
Bioswale			**861**	
Efficiency			**861**	
County Phase I/II MS4 Impervious			342.99	
County Phase I/II MS4 Pervious			518.01	
Forest Buffers		**6263.85**		
Efficiency		**2567.86**		
County Phase I/II MS4 Impervious		429.02		
County Phase I/II MS4 Pervious		2138.84		
Landuse Change		**3695.99**		
County Phase I/II MS4 Pervious		3695.99		
Stream Restoration				**249600**
Pound Reduction				**249600**
County Phase I/II MS4 Impervious				177599.99
County Phase I/II MS4 Pervious				72000.01
Wet Ponds and Wetlands			**3000.01**	
Efficiency			**3000.01**	
County Phase I/II MS4 Impervious			1000	
County Phase I/II MS4 Pervious			2000.01	
Grand Total	**0**	**6263.85**	**5751.01**	**249600**

POTENTIAL LAND USE LOADS

Table 149: Summary of Potential Scenario Land Use Loads by Subwatershed for Phosphorus to the Chesapeake Bay

Row Labels	Sum of Acres	Sum of PLoadEOS	Sum of PLoadDEL
Catoctin Creek	**7653.64**	**4975.96**	**2334.39**
County Phase I/II MS4 Impervious	1300.95	2766.06	1297.65
County Phase I/II MS4 Pervious	6352.69	2209.9	1036.74
Double Pipe Creek	**1427.22**	**1008.94**	**473.33**
County Phase I/II MS4 Impervious	240.86	366.15	171.78
County Phase I/II MS4 Pervious	1186.36	642.79	301.55
Lower Monocacy River	**31835.76**	**10562.94**	**4955.43**
County Phase I/II MS4 Impervious	5715.73	3571.5	1675.52
County Phase I/II MS4 Pervious	26120.03	6991.44	3279.91
Potomac River FR Cnty	**3656.79**	**3022.12**	**1417.77**
County Phase I/II MS4 Impervious	697.71	1808.86	848.6
County Phase I/II MS4 Pervious	2959.08	1213.26	569.17
Potomac River MO Cnty	**53**	**51.1**	**23.97**
County Phase I/II MS4 Impervious	9	25.94	12.17
County Phase I/II MS4 Pervious	44	25.16	11.8
Upper Monocacy River	**7532.97**	**3849.06**	**1805.72**
County Phase I/II MS4 Impervious	879.19	539.05	252.88
County Phase I/II MS4 Pervious	6653.78	3310.01	1552.84
Grand Total	**52159.38**	**23470.12**	**11010.61**

POTENTIAL LOAD REDUCTIONS

Table 150: Sum of Potential Edge of Stream and Delivered Phosphorus Load Reductions for the Chesapeake Bay Watershed

Row Labels	Sum of PLoadEOS	Sum of PLoadDEL
Catoctin Creek	**2634.18**	**1235.78**
County Phase I/II MS4 Impervious	1041.62	488.66
County Phase I/II MS4 Pervious	1592.56	747.12
Double Pipe Creek	**340.5**	**159.73**
County Phase I/II MS4 Impervious	319.14	149.71
County Phase I/II MS4 Pervious	21.36	10.02
Lower Monocacy River	**13445.79**	**6307.85**
County Phase I/II MS4 Impervious	9626.01	4515.85
County Phase I/II MS4 Pervious	3819.78	1792
Potomac River FR Cnty	**0**	**0**
County Phase I/II MS4 Impervious	0	0
County Phase I/II MS4 Pervious	0	0
Potomac River MO Cnty	**0**	**0**
County Phase I/II MS4 Impervious	0	0

County Phase I/II MS4 Pervious	0	0
Upper Monocacy River	**2440.48**	**1144.91**
County Phase I/II MS4 Impervious	1982.72	930.16
County Phase I/II MS4 Pervious	457.76	214.75
Grand Total	**18860.95**	**8848.27**

Lower Monocacy	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
	5,000,000		2,000	600	2,200	2,500	10,000	1,710	400	1,460	1,750	8,000		62,250
	500		3,000	500	6,000	600	113,000	1,000	400	1,700	200	500		
	5,000		2,500	150	220,000	20,000	1,075	15,000		275,000	450	150		
	10,000		3,750	1,000	1,000	20,000	500	162,000		13,890	450			
			10,000	750	1,000	250	5,760	300						
				150	100	180,000	500	5,170						
						500		500						
						1,000		12,000						
						500								
						300								
Count	4	0	5	6	6	10	6	8	2	4	4	3	0	1
Total Volume (gal)	5,015,500	0	21,250	3,150	230,300	225,650	130,835	197,680	800	292,050	2,850	8,650	0	62,250
Fecal Coliform (billion/year)	1,898,574	0	8,044	1,192	87,178	85,418	49,526	74,830	303	110,553	1,079	3,274	0	23,564

1 - SSOs reported in gallons

2 - Assume 10,000,000 MPN/100 ml in untreated sewage from WTM

Rainfall/Storm Events

Upper Monocacy	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
	5,000	1,000	8,000			500				51,160		4,505	960	2,000
	2,000	9,450	1,500										110	
		7,000	2,000,000											
			5,000											
			10,000											
Count	2	3	5	0	0	1	0	0	0	1	0	1	2	1
Total Volume (gal)	7,000	17,450	2,024,500	0	0	500	0	0	0	51,160	0	4,505	1,070	2,000
Fecal Coliform (billion/year)	2,650	6,606	766,357	0	0	189	0	0	0	19,366	0	1,705	405	757

1 - SSOs reported in gallons

2 - Assume 10,000,000 MPN/100 ml in untreated sewage

Rainfall/Storm Events

APPENDIX 17: WTM MODEL ASSUMPTIONS

The WTM requires inputs specific to the watershed. It also contains assumptions which can be modified. Slight modifications were made to the WTM where more specific information was available, and where changes were supported in the literature.

- Primary Sources:
  - Impervious cover estimates for *E. Coli* in the WTM are based on a land use land cover layer. The following land use coefficients are applied to Land Use Land Cover Data from the Maryland Department of Planning. They modify some categories in the WTM slightly to address differences between the County's urban densities and those in the LULC data in the WTM. The table below shows the coefficients:

Table 151: Percent impervious values assigned to 2000 Maryland Division of Planning land use data

Land Use Code	Land Use Class	Assigned Impervious Value
11	Low-density residential	9 %
12	Medium-density residential	21 %
13	High-density residential	28 %
14	Commercial	90 %
15	Industrial	70 %
16	Institutional	80 %
17	Extractive	80 %
18	Open urban land	8.6 %
21	Cropland	1.9 %
22	Pasture	1.9 %
23	Orchards/vineyards/horticulture	1.9 %
241	Feeding operations	1.9 %
242	Agricultural buildings	1.9 %
25	Row and garden crops	1.9 %
41	Deciduous forest	1.5 %
42	Evergreen forest	1.5 %
43	Mixed forest	1.5 %
44	Brush	1.5 %
50	Water	100 %
60	Wetlands	100 %
73	Bare ground	8.6 %

  - Annual rainfall: From the Frederick Airport
  - Watershed area: watershed minus municipal areas from GIS
  - Stream miles: stream miles clipped to the watershed boundary in GIS
  - Hydrologic Soil group and depth to groundwater: In GIS from NRCS clipped to watershed boundary minus municipalities
- Secondary Sources

- Dwelling units:
  - These were calculated in GIS using a planning data layer showing residential properties clipped to the watershed layer with municipalities deleted.
  - % Unsewered dwelling units: These were calculated by estimating the number of sewered residential parcels in GIS and subtracting them from the total number of parcels.
- Septic Systems:
  - % of septic systems <100' to waterway: 50% was used based on MDE's assumptions for the Phase II WIP
  - Soils: Clay/mixed dominant soils from NRCS
  - System type: assumed to be 100% conventional as this type dominates in Frederick County.
  - Typical separation from groundwater: 5 feet
  - Current septic system management: medium
- SSOs:
  - Modeled outside of WTM using data from Division of Utilities and Solid Waste Management
- Illicit Connections: Businesses from planning layer
- Urban channel
  - Method 1 standard assumption of channel erosion

- Existing Management Practices: Serves as baseline and does not change between model runs.
  - Pet waste education: no
  - BMPs: assume zero for existing scenario
  - Riparian Buffers: calculated from forest layer using 35 foot buffer calculation using total area of forest within the buffer
  - Maintenance: .4, no ordinance
- Future Management Practices: Changes for each model run. WTM1 represents **Completed**, WTM2 is **Programmed**, WTM3 is **Identified** and WTM4 is **Potential**.
  - Pet waste education:
    - **Completed:** No
    - **Programmed**, **Identified**, and **Potential:** yes for all scenarios. From Swann (1999), use multiple outreach methods including television, assume maximum awareness percentage (45%) and maximum behavior change (56%), resulting in 25% program efficiency.
  - Riparian buffers: From BayFAST run. Acres converted to miles at 35 foot buffer.
    - Maintenance
      - **Completed:** .4, no ordinance
      - **Programmed**, **Identified**, and **Potential:** .9, ordinance, enforcement, education
  - Stormwater retrofits: Load reductions for wet ponds, wetlands, and filters were not changed from the number given in the WTM. Hunt et al. (2008) found the bacteria removal efficiency of bioretention practices to be 70%. The manner in which the County implements bioswales fits with the Watershed Treatment Model's definition of a bioretention practice; therefore bioswale was given a 70% reduction as well. Scenarios for the WTM for structural stormwater management retrofits come from BayFAST models for each watershed for the TMDLs for sediment and phosphorus.

        - **Completed, Programmed**, **Identified**, and **Potential:** from BayFast model runs for phosphorus and sediment TMDLs for each watershed.
    - Illicit Connection Removal: 100% of the system is surveyed with varying percents of repairs made.
    - SSO Repair/Abatement: This section of the model was not used because inputs to the model would have resulted in values that did not accurately reflect actual fecal coliform loading. Instead, fecal coliform loading was calculated by the Division of Utilities and Solid Waste Management using data from reported SSOs dating back to 2003. The County has an SSO abatement program and has shown a downward trend of SSOs over time.
    - Septic System Education: A 40% willingness to change is assumed based on Swann (1999) and an awareness factor of 40% is used for a media campaign that includes television.
    - Septic System Repair: Repairs are based on 100% inspection and a repair rate consistent with the number performed by the Health Department for each watershed over a five year period. Septic repairs fix a failing septic system. The Health Department has reported 102 of these in the past 5 years. 50 are attributed to the Upper Monocacy, 40 to the Lower Monocacy, and 12 to Double Pipe Creek.
    - Septic System Upgrade: 5 septic systems in Double Pipe Creek have been upgraded in the past 5 years, along with 65 in the Lower Monocacy and 60 in the Upper Monocacy. These data were reported by the Health Department. Each model run includes another five years of data.
    - Septic System Retirement: The County has completed seven of these in the past ten years. This information was reported by the Planning Department.
- New Development
    - Forested land uses are added and vacant lots are reduced commensurate with the number of acres of forest buffers planted. This is to address the land use change portion of the riparian buffer BMP.